POWER

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FIRELESS HELP

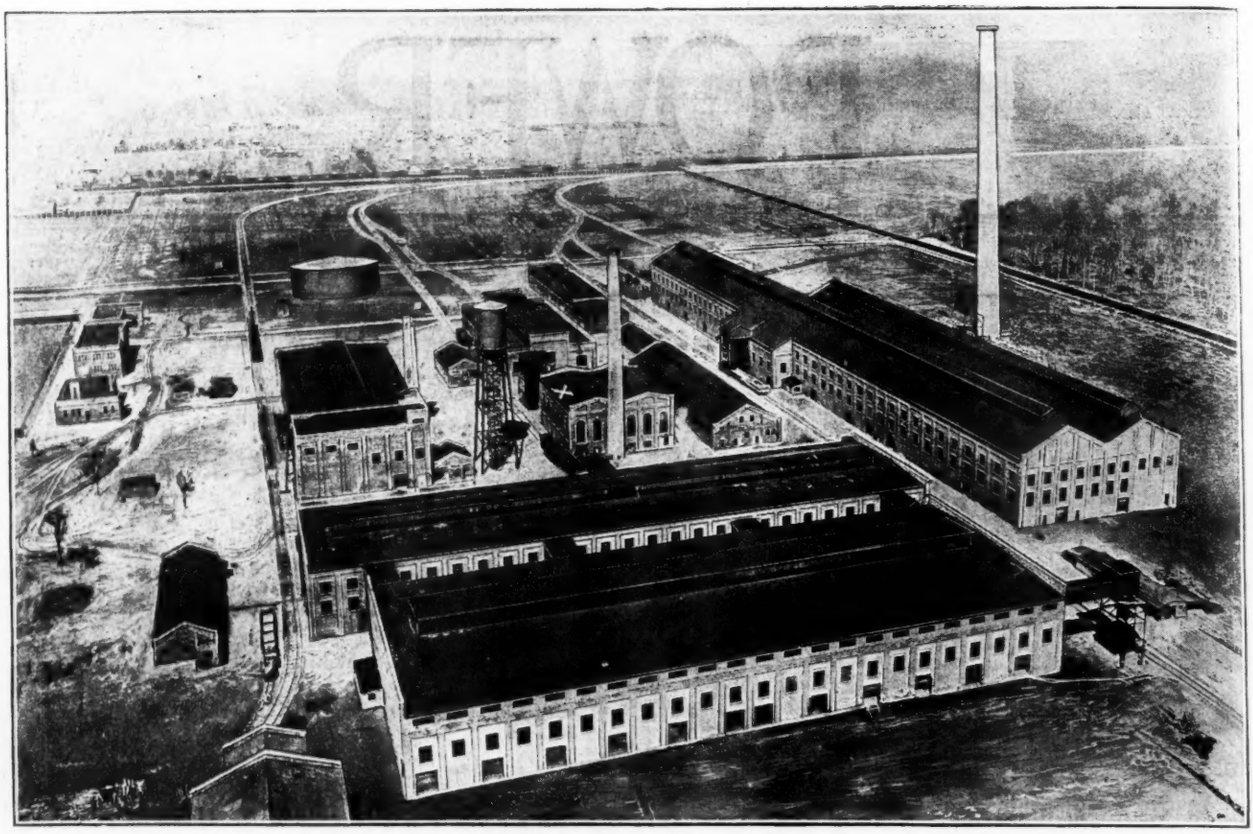
By Rufus T. Strohm

Harold Percy Cecil Peters
(Ain't that moniker a crime?)
Tendin' boilers, pumps an' heaters,
Gits his features smeared with grime.
Harold ain't no howlin' wonder
As a helper, that we grant,
But we grin an' knuckle under,
For his daddy owns the plant.

Dad has got the grand idea
Firmly stuck between his ears
That his offspring oughta be a
Future chief of engineers;
Now, the boy don't have the makin',
But we never tell him so,
For we'd only burn our bacon,
Since his pater runs the show.

Have we troubles? Lord 'a mercy,
I should rather think we do!
Every day young Harold Percy
Pulls a bonehead play or two;
An' although we're mad an' tired,
We conceal the boob's disgrace,
For we know he can't be fired,
Since his father owns the place.

Engineerin' life is pleasin'
An' it's never dull or tame,
For you've got to hunt the reason
When the plant goes runnin' lame;
But you'll find your power station
Showin' new an' funny quirks
If the boss's near relation
Gits a job around the works.



High-Speed Direct-Current Generator and Turbo-Blower Power Plant

Two 1,000-Kw. Direct-Current GeneratorOperating at 1,700 r.p.m., Two 1,000-Hp. Blowers Operating at 8,500 r.p.m. – Waste-Heat Boilers Used on Nickel-Refining Furnaces – Circulating Water from Rabble Arms in Calciner Furnaces Used for Boiler-Feed Water – Other Features in Power-Plant Construction of Particular Interest.

By H. W. SPOONER* and F. A. ANNETT†

LOCATED at Port Colborne, Ont., Canada, near the Lake Erie entrance of the Welland Canal, on a 330-acre tract of land, is the refinery of the International Nickel Company of Canada, Ltd. (see headpiece). Late in 1916 it was decided by the International Nickel Co. to construct a nickel-refining plant in Canada of sufficient capacity to meet the needs of the British Empire, which were very urgent at that time on account of the war. Nickel matte is received from the smelters at Sudbury, Ont., where the mines are also located, and is converted into refined nickel and nickel oxide at Port Colborne. A monthly production of 1,250,000 lb. of refined nickel and 500,000 lb. of copper represents the chief output. The plant consists of 31 buildings of steel and brick construction designed and built by The Foundation Co., New York City, and is situated about one-half mile from either the Welland Canal or Lake Erie. When the power supply for this plant was considered, there were two sources to choose from. The first was purchased power from either the Hydro-Electric Commission of Ontario or from the Dominion Power and Transmission Co., both of which have transmission lines running into Port Colborne. Under ordinary conditions these companies would have offered very attractive rates for this load, which would have been fairly constant and amounted to approximately 10,000,000 kw.-hr. per year. A second and only other source of power was the installation of an isolated plant at the works. After carefully investigating the various factors entering into the problem, the latter course was adopted. This decision was influenced largely by the fact that great quantities of live steam and hot water are required in the manufacturing processes and large amounts of waste heat are available from the refining furnaces. Furthermore, on account of the shortage of power existing on the Niagara Peninsula for the last four or five years, the two companies having transmission lines running into Port Colborne were not in a position to

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guarantee a satisfactory power supply. This was substantiated during the war, when some of the industries were shut down or operated only on part time because of the power shortage.

A unique feature of the power plant, shown at *X* in the headpiece, is the high speed at which most of the machinery operates. The 1,000-kw. turbo direct-current generators have a speed of 1,700 r.p.m.; 1,000 hp. blowers, 8,500 r.p.m., and the turbines driving the condenser pumps run 5,700 r.p.m.; there are also a number of other high-speed turbine-driven pumps. Out in the plant there are three 90-hp. direct-current motors direct-connected to blowers that operate at from 2,300 to 3,600 r.p.m. These blowers have a normal capacity of 7,500 cu.ft. and a maximum capacity of 12,000 cu.ft. of free air per minute raised to 1.75 lb. pressure. The only reciprocating unit of importance in the plant is the 200-hp. air compressor shown in the foreground, Fig. 2.

The adoption of direct current was largely influenced by the heavy crane load, which makes up a considerable part of the current consumption in the entire plant. An additional factor in the advantage of direct current was the desirability of using series-wound motors for tilting the copper converters and adjustable-speed, field-control motors for driving the cupola blowers, in which a considerable variation in speed and pressure was necessary.

Coal Handling Equipment

Coal for the power plant is received by rail and either stored in the yard adjacent to the plant or dumped from bottom-dump cars into a track hopper, from which it passes down through a coal crusher into a pit. From the pit the coal is elevated vertically by a bucket conveyor to the top of the coal tower and delivered upon a belt which conveys it over the firing aisle into a 200-ton steel bunker lined with brick on edge. A traveling automatic tripper unloads the belt into the bunker at any desired point. The coal-handling equipment has a capacity of about 50 tons per hour. When coal is to be stored in the yard it is unloaded from the cars with a yard crane and clamshell buckets, and is recovered in the same way. About 100 tons of coal is required per day in the operation of the entire plant, 50 per cent of which is used for steam generation and 50 per cent in the refining processes. In addition to the power-house coal bunker there is one of reinforced-concrete construction in the calcining building, 380 ft. in length, having a capacity of 1,000 tons. Coal for this building is handled in practically the same way as for the power plant.

Coal-Fired Boilers

In the boiler plant there are four 400-hp. Babcock & Wilcox water-tube boilers equipped with chain-gate stokers. The boilers are set in batteries of two each, and space is provided for two additional units. All the boilers and stokers in the power plant were manufactured in Scotland. Although the coal used at this time is of no particular grade, being whatever may be purchased, it is possible to force the boilers up to 200 per cent of their normal rating. Each boiler has 196 tubes arranged 14 high by 14 wide, baffled for three passes (see Fig. 4). The front and rear headers are connected by two 42-in. steam and water drums. Each tube is 18 ft. long by 4 in. in diameter, giving the boilers each 4,390 sq.ft. of heating surface. The superheaters have

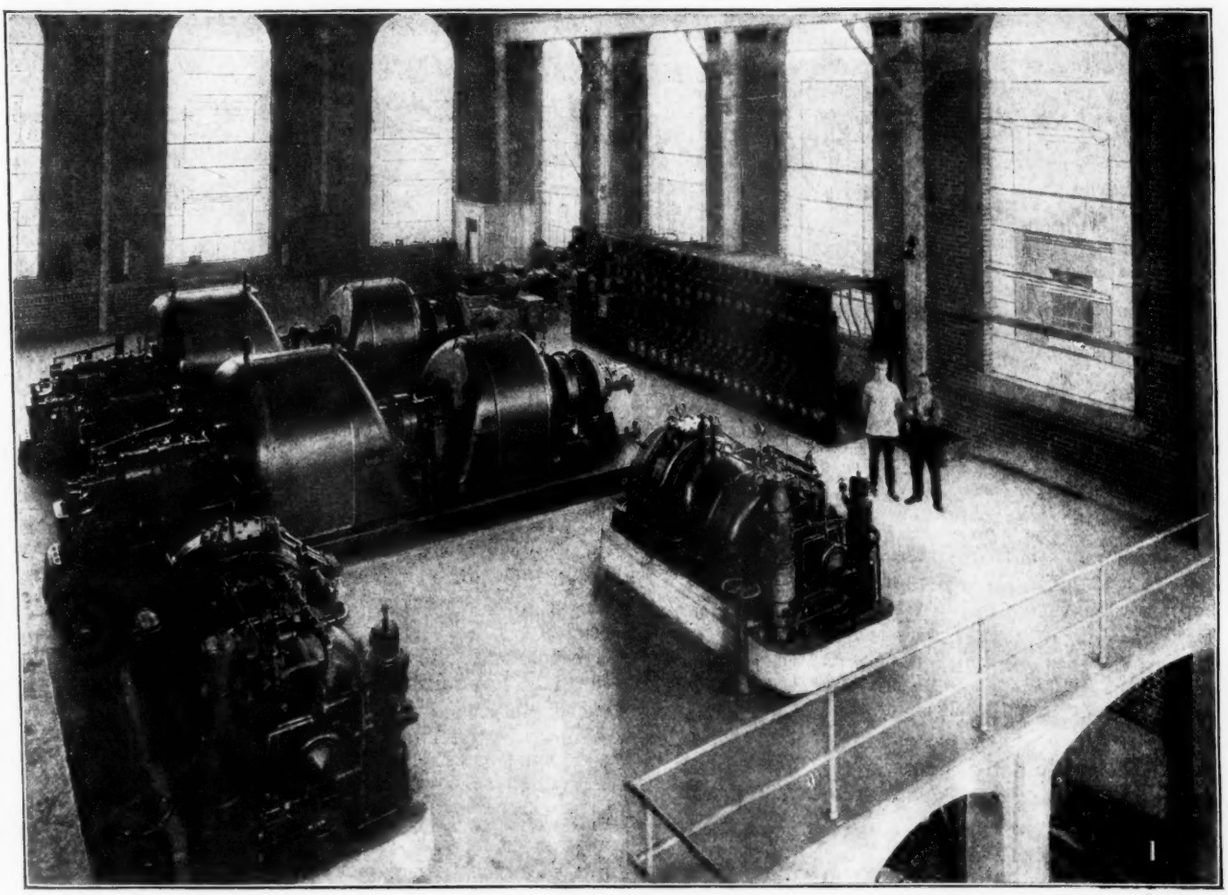


FIG. 1. VIEW OF MAIN GENERATOR ROOM, TURBO-BLOWERS IN FOREGROUND

770 sq.ft. of heating surface and are of particular interest since they differ in shape from those used in American practice, as is clearly indicated in the figure. A reinforced-concrete chimney 175 ft. high by 8 ft. inside diameter furnishes the draft for the boilers. The draft for each boiler is controlled through dampers in the downtake by automatic damper regulators.

Located under the boiler-room floor at the rear of the boilers is the concrete flue, lined with brick, connecting to the chimney, which is outside of the boiler room. The chimney is brick-lined for approximately one-third its height.

Coal from the bunkers is delivered through chutes to the hoppers on the front of the stokers, which are belt-driven from a lineshaft operated by an adjustable-speed motor, as shown in Figs. 5 and 6. The speed of the stokers can also be controlled by differential gears. The coal in passing into the furnace is carried under a coking arch 7 ft. long and 2 ft. high; by this means it is possible to obtain practically smokeless combustion at all loads. Although economizers are not used, the gases go to the chimney at a temperature of about 450 deg. Each stoker has an active grate area of 7 by 12 ft., or 84 sq.ft., giving a ratio of grate area to boiler-heating surface of 1 to 52.

Ashes from the stokers fall into reinforced-concrete brick-lined hoppers from which they are dumped into a small side-dump car and are run through a tunnel to the coal tower and dumped into a pit from which they are elevated into a concrete bin in the tower. At given intervals the ashes are delivered to railway cars and are hauled away.

Waste-Heat Boilers

In the nickel-refining plant, shown to the left of the water tower in the headpiece, are two 400-hp. American B. & W. waste-heat boilers, Fig. 3, each having 260 tubes 4 in. by 18 ft., arranged 10 wide and 26 high, baffled for three passes and equipped with superheaters. Gases from two refining furnaces pass through these boilers, one boiler on each furnace. One furnace is usually in service when the other is down for relining; thus only one boiler is in operation at a time. The waste-heat boiler allows the taking out of service of one unit in the power plant. Each boiler is served by a concrete chimney 100 ft. high. Additional draft, to overcome the frictional resistance through the boilers, is obtained by an induced-draft fan driven by a 35-hp. adjustable-speed motor. In this installation the gases go to the chimney at a temperature of around 650 to 680 deg. F. In addition to those which serve the boilers, there are two reinforced-concrete chimneys, each 350 ft. high by 12 ft. inside diameter at the top; these are used in connection with the cupolas and the reverberating and roasting furnaces in the process buildings. When the gases leave the nickel-refining furnaces,

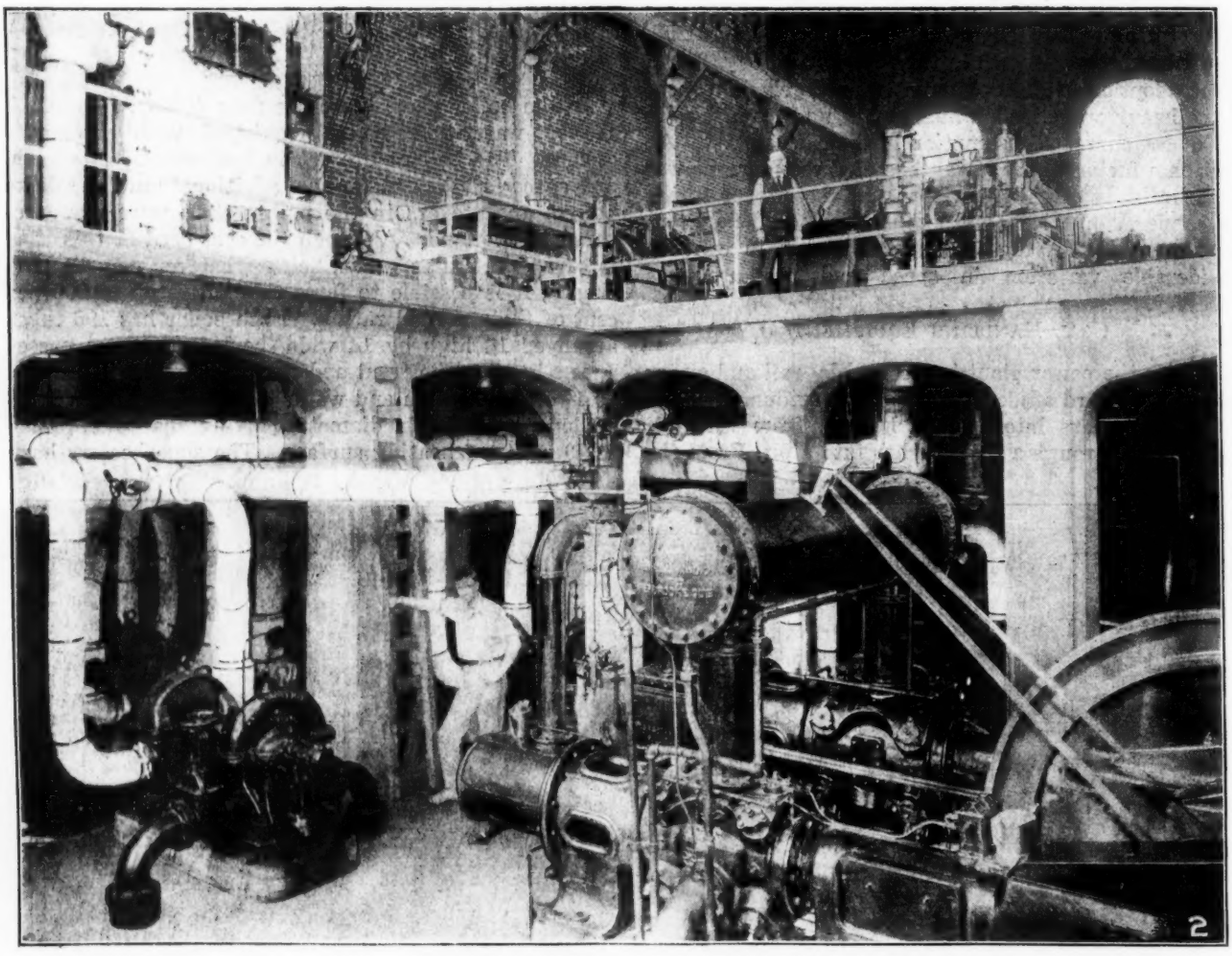


FIG. 2. VIEW OF PUMPROOM BELOW AND GENERATOR ROOM ABOVE

they pass through a series of chambers located in the underground flues between the furnaces and the boilers, where they drop a large percentage of the solid materials from them before they go to the boiler. In addition to this the boiler tubes are blown down every eight hours,

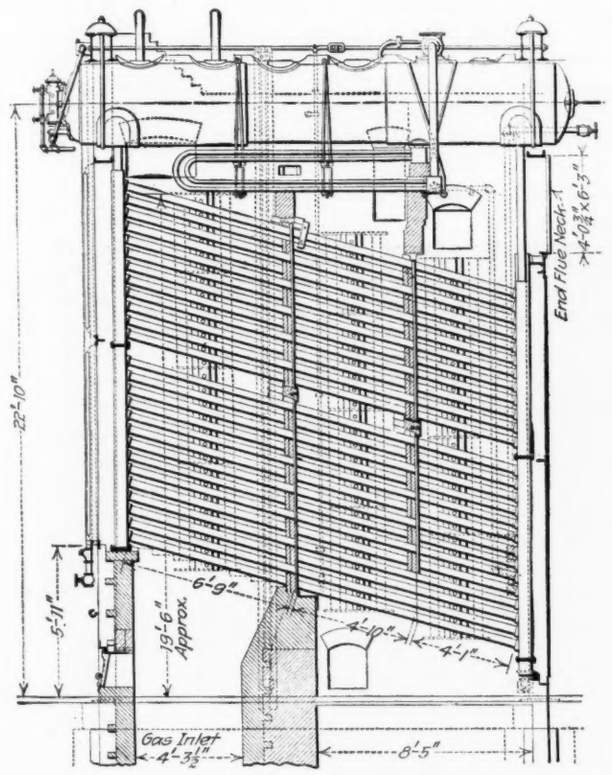


FIG. 3. SECTION THROUGH WASTE-HEAT BOILER

and as a result no difficulty has been experienced from deposits on the outside of the tubes.

All boilers operate at 150 lb. gage pressure and are connected into two steam headers, one 3½ in. in diameter for saturated steam and the other 10 in. in diameter for superheated steam. Large quantities of saturated steam are reduced from boiler pressure down to from 50 to 10 lb. through reducing valves, for use in the refining processes. Steam at 10-lb. pressure is also used during the winter months in the heating system of all buildings requiring heat, such as offices, clubrooms, washrooms, etc.

Power-Plant Equipment

Adjacent to the boiler plant is the turbine room, on the main floor of which (Fig. 1) are two 1,000-kw. 250-volt, 4,000-ampere, Rateau-Battu-Smoot Co. direct-current generators directly connected to Ridgway-Rateau steam turbines operating at 1,700 r.p.m. Space has been provided for one additional unit. For their size these are two of the highest speed direct-current generators in operation. The field frame of one of these units is shown in Fig. 7, and the armature in Fig. 8. A more detailed description will be given in a future issue. On the main turbine-room floor there are also two 1,000-hp. turbo-blowers operating at 8,500 r.p.m., of the same make as the generators. In addition to these are the main switchboard of 13 panels, 2 balancer sets for the 250-125-volt three-wire system, 2 open feedwater heaters and meters, also gage boards on which are mounted instruments to give steam, air and oil pressure. Under the main floor of the turbine room, Fig. 2, are located all auxiliaries, including the boiler-feed pumps, consequently there is no equipment under the boiler room except the ash car. This arrangement isolates all moving machinery from the ash and coal dust of the boiler room, which greatly reduces the amount of work required to keep them clean and in good operating condition.

Steam enters the main turbines at 150 lb. pressure and 100 deg. F. superheat, or a total temperature of 466 deg; and is exhausted down to 28.25 in. vacuum through Westinghouse Le Blanc jet condensers. The condenser pumps are of the rotating type, mounted on the same shaft, and are driven by 31-hp. turbines operating at 5,700 r.p.m., geared down to the speed of the pump. Each condenser is capable of handling 17,500 lb. of exhaust steam per hour and maintaining a 29-in. vacuum with 40-deg. cooling water. Condensing water is taken from the cold well running under the center of the pumproom. The condenser water discharges into a hotwell or conduit, which discharges into the storm sewer and thence into Lake Erie, about one-half mile away.

In the foreground of Fig. 1 are shown the two 1,000-hp. 8,500-r.p.m. turbo-blowers used for supplying air to the furnaces converting matte into blister copper. Each of these units has a capacity of 15,000 cu.ft. of

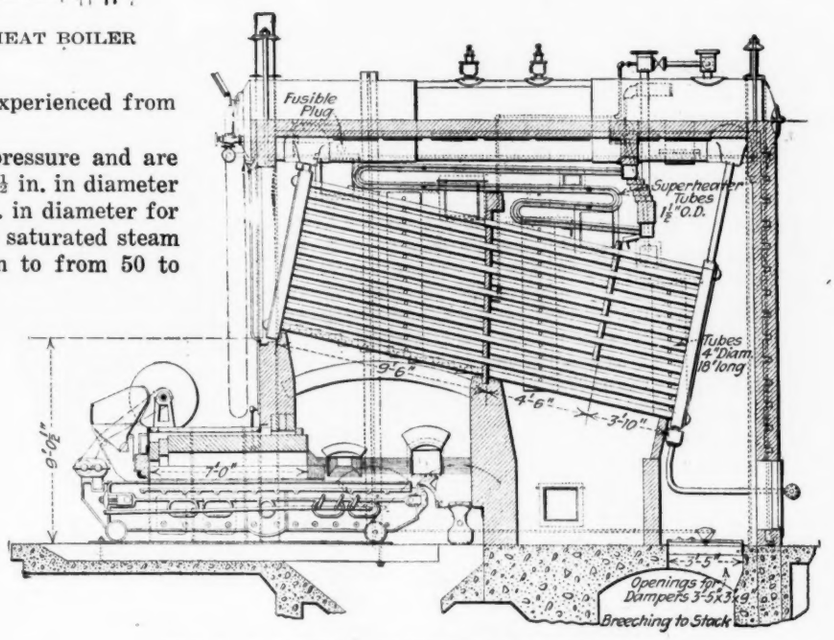


FIG. 4. SECTION THROUGH COAL-FIRED BOILER

free air per minute raised to 15 lb. pressure. The turbines driving these blowers operate on steam at 150 lb. gage and 100 deg. F. superheat and also exhaust into Le Blanc jet condensers which are capable of condensing 11,000 lb. of steam per hour and maintaining a vacuum of 29.05 in. with condensing water at 40 deg. F. A 21-hp. geared turbine is used to drive the air and cooling-water

pumps on these units. All main bearings of the blower units are force-lubricated and water-cooled. A comparison of the size of the blower unit with the men standing in Fig. 1 will give some conception of the economy in space realized by the use of blowers operating at such high speeds over those of the old reciprocating type of blowing engine operating at slow speeds. (For a more detailed description of these blowers see Mar. 23, 1920, issue of *Power*, page 450.)

Three other blowers of special interest are those used to supply air to the nickel and copper cupolas. Each of these blowers has a normal capacity of 7,500 cu.ft. of free air per minute raised to 28 oz. pressure and is directly connected to a 90-hp. motor operating at speeds from 2,300 to 3,600 r.p.m. These units are also of the Ridgway-Rateau make. The generators are of the two-wire type, but a three-wire lighting system was installed throughout the plant, with two motor-generator balancer sets for taking care of the unbalanced lighting load. The manual operation required to place one of the balancers on the line consists merely in closing a double-pole switch on the balancer panel in the main switchboard. This brings into action an automatic motor starter, and after the machine has come up to speed an automatic switch is closed in the neutral lead, placing the unit on the line. An inverse time-limit overload relay is connected to the automatic single-pole switch in the neutral lead, adjusted to trip in 20 sec. at 400 per cent load, for the protection not only of the balancer sets, but also of the lights about the plant.

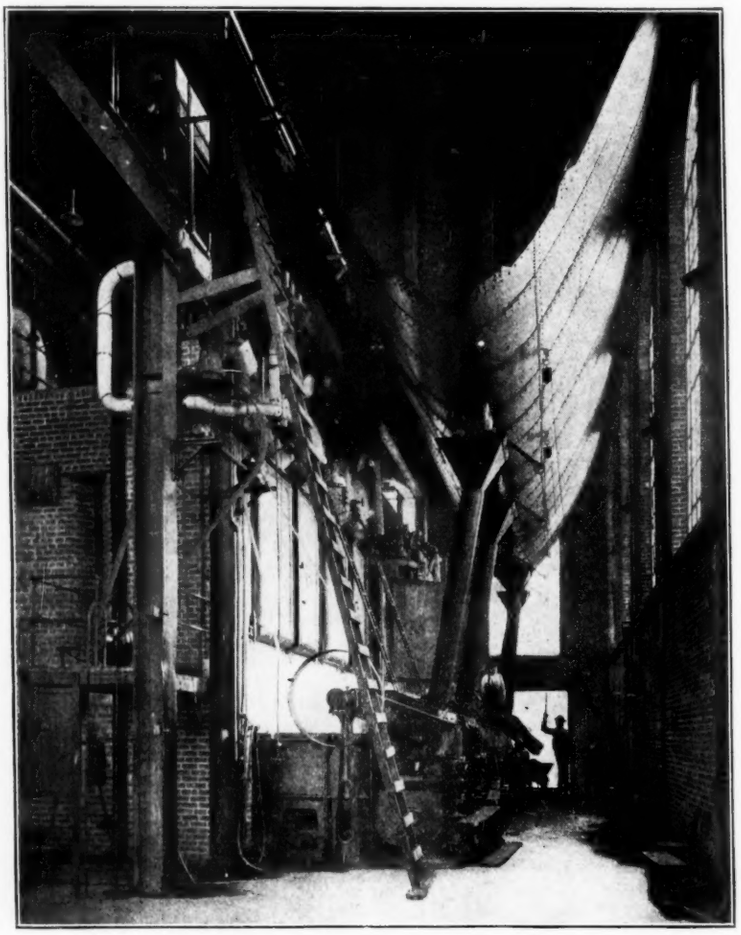


FIG. 5. FRONT OF BOILER ROOM, SHOWING COAL BUNKERS AND STOKERS

An emergency lighting system is provided for the power plant. The lamps in this system are neither as large nor as numerous as those in the regular 110-volt lighting system, but they are distributed at all necessary points in the turbine room, pumproom, and boiler room. The current for these emergency lights is obtained from a duplicate installation of 32-volt storage batteries. This system is automatic and in the event of failure for any reason of the regular lighting system in the power plant the closing of an automatic switch cuts in the emergency lights. The storage battery also serves other purposes about the power plant.

The thermodynamic problems involved in the design of this plant were of considerable interest and of great importance in regard to possible savings in fuel. A large quantity of circulating water is used in the calciner building for cooling the rabbles in the mechanical calcining furnaces, and large quantities of hot water are used in the vats in the leaching building. The problem was to raise the temperature of this circulating water to approximately boiling point with the use of a minimum quantity of steam and, of course, preferably by using exhaust steam. It was also necessary to soften the water, not only for the leaching processes, but also for boiler-feed purposes as well. The short length of the hand calciner furnaces as compared with the mechanical furnaces afforded ample room for the installation of the water-softening system in the calciner building. This system was built and installed by William B. Scaife & Sons Co., of Pittsburgh, Pa., and consists of three large treating tanks and one small filter tank, all of wood-stage construction, and was designed for treating hot water. Circulating water is discharged from the rabbles in the five mechanical calcining furnaces at an average temperature of 160 deg. F. and flows by gravity through a main to the pump pit near the treating tanks. In this pit are three motor-driven centrifugal pumps, which are used to deliver the raw water into the treating tanks and the treated water to the power house. The piping is so arranged that any one of the three pumps can be used for either service, and as only two pumps are required to do the work the third is held in reserve as a spare unit. A storage reservoir, built of reinforced concrete, is provided at one side of the pump pit. This is divided into halves, one side being used for raw water and the other for treated water; both reservoirs are on the suction side of the pumps. Treated water is carried through a 6-in. pipe from the calciner building through an underground tunnel into the power house and up through the turbine-room floor to the water heaters. There are two open-type heaters, built by Warren Webster & Co. and equipped with Lea V-notch meters and recorders. The larger of these heaters has a capacity of 200,000 lb. of water per hour, raised in

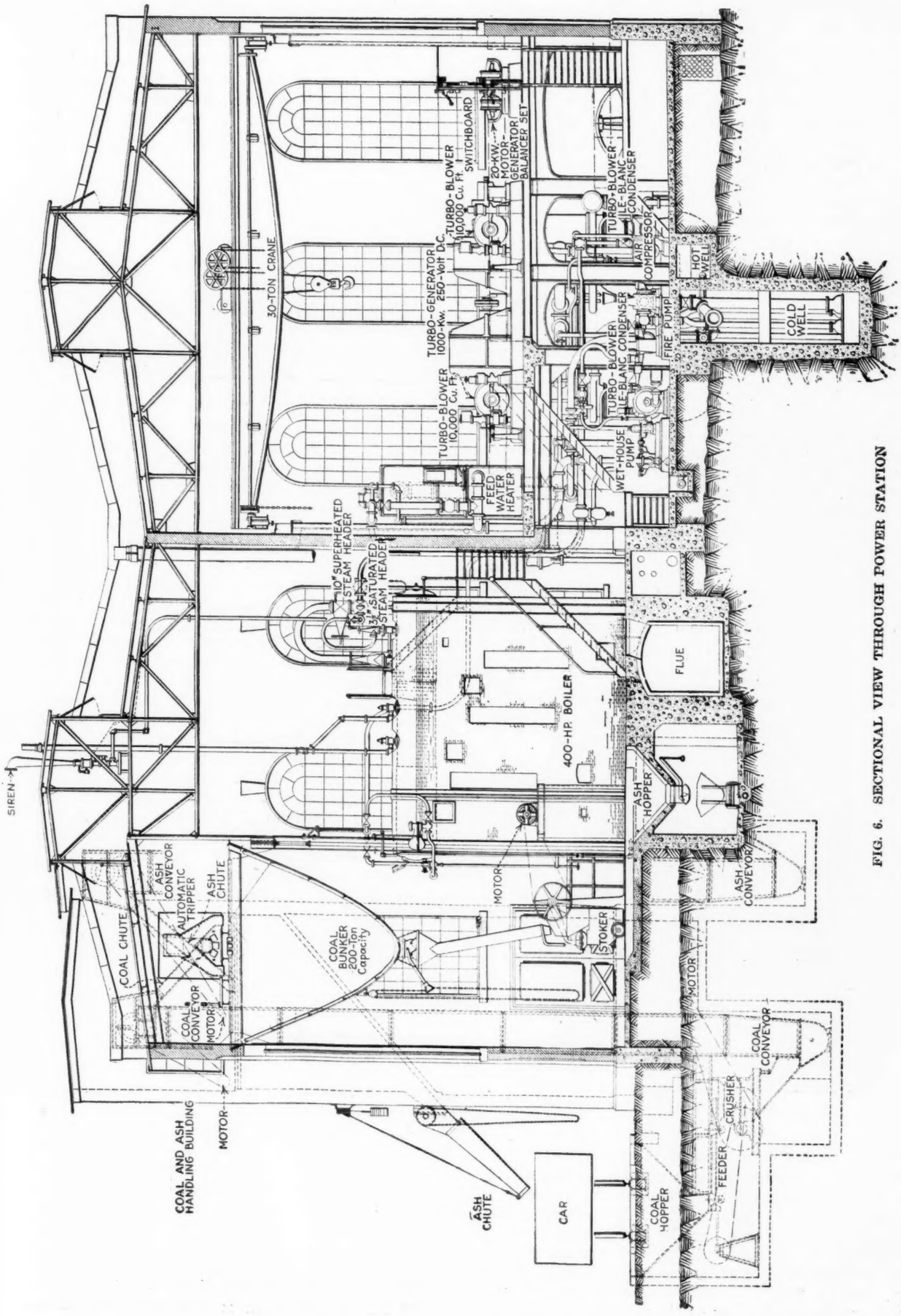


FIG. 6. SECTIONAL VIEW THROUGH POWER STATION

temperature from 150 deg. to 210 deg. F. and supplies the hot water for the leaching tanks. Two turbine-driven centrifugal pumps in the pumproom are used for pumping this water to the leaching building. The smaller heater has a capacity of 80,000 lb. of water per hour under similar conditions of temperature and is used for heating the feed water for the boilers in the main power house and also for the waste-heat boilers in the refinery building. The difference in elevation between the pumps and the heaters insures a static head of about fifteen feet at the suction inlet to the pumps.

Exhaust for Heating Water

In the pumproom there are eleven small turbines. Four of these drive the pumps of the Le Blanc condensers used in connection with the turbo-generators and turbo-blowers. Two drive the main water-supply pumps, two the boiler-feed pumps, two the hot-water pumps, and one the fire pump; all these pumps being of the centrifugal type. In addition there is a cross-compound air compressor developing about 200 indicated horsepower at rated capacity.

Exhaust pipes from all these small turbines are connected into a main that runs through the pumproom, near the boiler room wall. A 12-in. branch rises from this main through the turbine-room floor and is connected into both water heaters through a single tee and two gate valves. Thus the exhaust steam from the

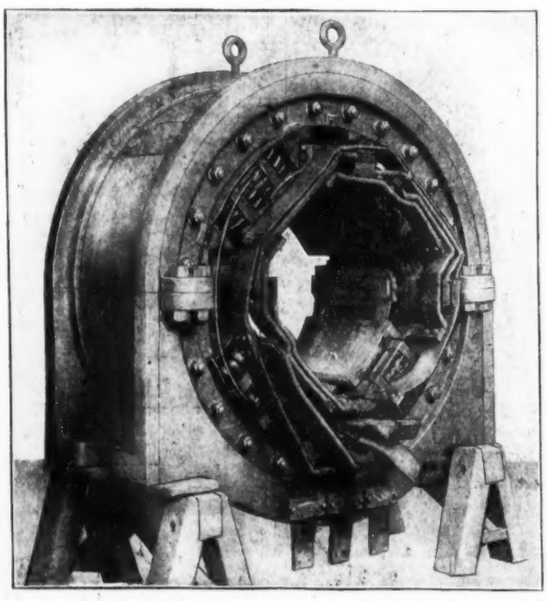


FIG. 7. DIRECT-CURRENT GENERATOR FIELD FRAME

pumps is used for heating all the hot water for the plant. On the bottom of each of the turbines driving the 1,000-kw. generators are two bleeder connections, and each of these is piped into the exhaust main. A 5-in. high-pressure bleeder connection is taken out of the third stage of the turbine, in which the pressure never goes below 15-lb. gage under any condition of operating load, and an 8-in. low-pressure bleeder connection is taken into the sixth stage of the turbine, in which the pressure never exceeds atmosphere. Automatic control valves in the low-pressure bleeder connections are adjusted for whatever back pressure it is desired to carry in the exhaust main connecting the auxiliary turbines and open heaters. Should the exhaust steam exceed the amount required to heat the water to the temperature corresponding to the back pressure, these valves open and permit the surplus steam to enter the

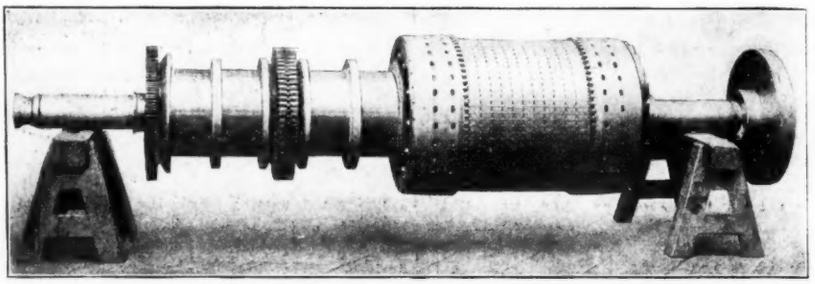


FIG. 8. DIRECT-CURRENT GENERATOR ARMATURE

main turbines, where it is expanded through four additional stages. If the quantity of exhaust steam from the small turbines is less than that required to heat the water, the pressure in the exhaust main drops, permitting other automatically controlled valves in the "high-pressure" bleeder connection to open and pass sufficient steam to make up for the deficiency. In this way an entirely closed system is obtained without loss of steam, and all surplus exhaust steam is made to do useful work in expanding from atmospheric pressure to the pressure in the condensers. The exhaust from the air compressor is connected into the low-pressure bleeder connections, closely adjacent to the bottom of each turbine, so that any cylinder oil in the exhaust steam may be prevented from entering the exhaust main and finding its way into the feed water or leaching water.

It is obvious that the low-pressure bleeder connections are not under control of the governors on the main turbines; consequently, if a heavy ground or short-circuit should occur anywhere about the plant, sufficient to blow the main circuit breakers in the generator leads, and if at the same time the turbine was bleeding in a considerable quantity of surplus exhaust steam, the unit would be in imminent danger of running away. The turbines are of course provided with overspeed trips, but these control butterfly valves in the main steam pipe and have no connection with the bleeder valves. To guard against a contingency of this kind an automatically controlled motor-driven valve, power for which was supplied from the storage battery, was provided for in the original design, in each of the low-pressure bleeder connections, so that in the event of loss of voltage the motor would be started and close the valve, thus diverting the surplus steam through the atmospheric relief valve. However, the bleeder on the turbo-generators was not placed in service at the time of installation due to the large quantities of high-pressure steam required in the leach house under forced production. Owing to the increased cost of coal since the plant was put in operation, it has been decided to dispense with high-pressure steam in the process, and use hot water from the large heater in the power house. This necessitates using the bleeders on the turbo-generators to give a sufficiently high temperature, so that all exhaust steam is used either in the feed

water or the process with a make up from the turbo-generators. The exhaust from the air compressor is now carried to the heaters with an oil separator placed in the line to prevent oil from entering the feed water.

Method of Supporting Machinery

The method of supporting the turbo-generators and turbo-blowers is rather unsual, but has some marked advantages in the saving of concrete and the gaining of additional space around the condensers which might otherwise be occupied by heavy foundations. Each generating unit is carried on eight reinforced-concrete columns, 24 in. square, four columns under each side. A continuous girder runs longitudinally under each side, tying the columns together, but the space between these girders, under the turbine and the generator, is almost entirely open. The condenser is set directly under the exhaust opening at the bottom of the turbine.

Each turbo-blower is carried on two reinforced-concrete girders extending 30 in. below the floor line and with a clear span between columns of 15 ft. The entire floor is a reinforced-concrete slab 12 in. thick, and the complete construction of walls, columns, girders and floors is monolithic, without the provision so frequently employed of separating the machinery foundations from the building construction. It should be said not only to the credit of the designers and builders of the plant, but also to the credit of the builders of the turbo-generators and turbo-blowers, that there is no perceptible vibration in the floor or other parts of the building.

Water-Supply for the Plant

The water supply for the entire plant and the main air ducts to the turbo-blowers and to the generators are incorporated in this general construction. A cold well 16 ft. deep extends the length of the building under the pumproom floor. Running crosswise of the generating units, it passes directly under their condensers and between the condensers for the turbo-blowers. The supply pumps for water distribution throughout the plant, the fire pumps and all the condensers have their suction lines extending into this cold well, to a depth below the minimum lake level. An underground intake conduit 4 ft. square, cut partly in solid rock and lined with concrete, extends to a screen chamber at the side wall of the Welland Canal, more than half a mile away. Through this conduit the entire water supply for the plant flows by gravity; up to 50,000,000 gal. per day may be obtained.

At the power-house wall, where the intake culvert enters the cold well, is a sluice gate operated by hand from the pumproom floor. In case of extremely high water, which might occur during a severe storm from the southwest, this sluice gate may be partly closed to control the water level in the cold well. On the wall facing the gate wheel is an indicating liquid-level gage, showing the elevation of the water in the cold well. This gage is graduated to show the elevation above sea level and is equipped with both high and low water alarms which close a circuit to an electric gong.

The air supply to the turbo-blowers and turbo-generators enters the cold well at the end of the building opposite the water inlet, through a 66-in. ventilator supported on a circular well curb just above the ground level. Passing over the water, air is taken into the blowers and generators through elbows cast in the concrete and thence through galvanized-iron ducts which rise vertically from the floor to the inlets on the bottom of the machines. The discharge of warm air from the generators is handled in a similar manner, vertical ducts carrying the air from the discharge outlet on the bottom of the machine through the pumproom floor, where they pass into the hotwell and to the open air through one end of the building. These discharge ducts have dampers that may be set to divert any part or all of the warm air from the generators into the pumproom, thus heating this room and the turbine room in severe weather.

To prevent freezing of the water in the cold well in winter, due to a large volume of cold air passing over its surface, provision is made for diverting into the cold well any part of the discharged cooling water from either of the condensers serving the turbo-generators.

This article would not be complete without some reference to the sanitary system. All sewage is discharged to a disposal plant, located in the sand dunes near the shore of Lake Erie, and constructed on the activated-sludge process. This process provides for the aëration and clarification of the sewage, and the effluent is free from all objectionable matter. The air supply for the activated-sludge chamber is taken from the underground main through which air is supplied to the converters by the turbo-blowers in the power house. It is obvious, therefore, that the operation of this system is highly economical. The installation was made on the recommendation of the Provincial Board of Health of Ontario and has resulted in entirely eliminating any polluted water from the plant being discharged into Lake Erie.

Semi-Diesel and Hot-Bulb Engine Suggestions

Don't use a lubricating oil that does not flow readily. If very viscuous, the oil may fail to reach the crankpin.

When a crankpin bearing heats, it should be removed and the babbitt dressed. Examine the oil holes through the pin, for the melted babbitt frequently closes up the oil passage.

Semi-Diesel engines frequently gum the piston rings. If the fuel oil is heavy, the piston and rings will require cleaning every sixty days or less.

In removing rings don't extend them too far. Rings are very brittle, being cast iron. If four thin strips are inserted between the ring and piston, the removal is easy.

Don't have more than 0.01 inch play between the ring and the side of the groove. If it is more, the ring and groove will wear very rapidly. If the groove is worn, turn it up on a lathe and use wider rings.

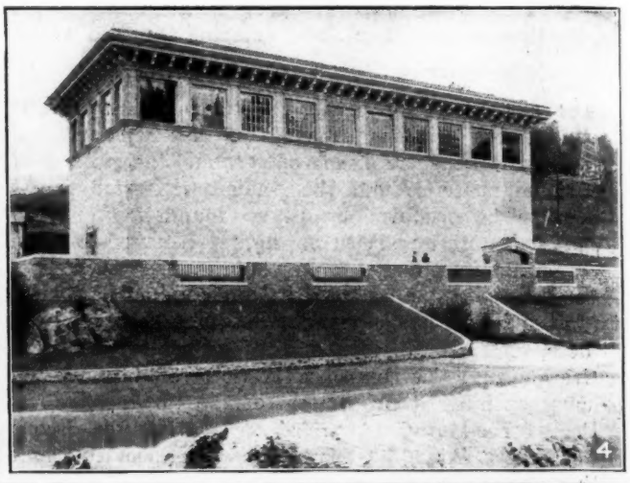
Fire-cracks in the piston head are best repaired by sewing.

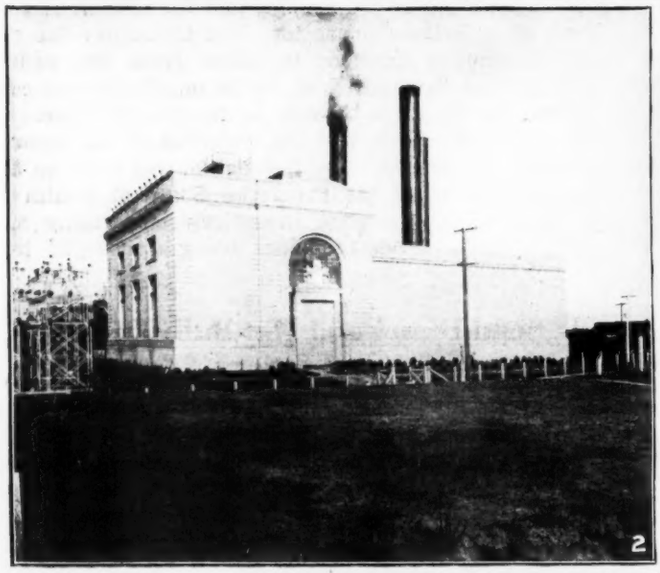
If the engine pounds although the connecting-rod bearings are snug, probably the piston "slaps" because of wear. This "slap" will be quite violent if the piston and crankpin bearings are not in line.

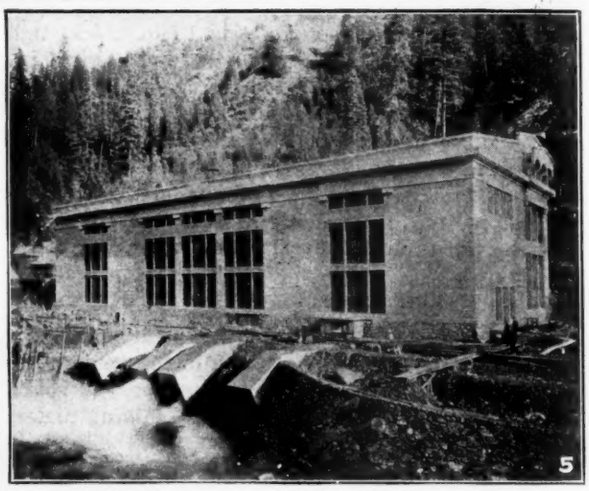
No carbon deposits should be left on the piston head. Frequently, this carbon becomes intensely hot and will cause preignition.

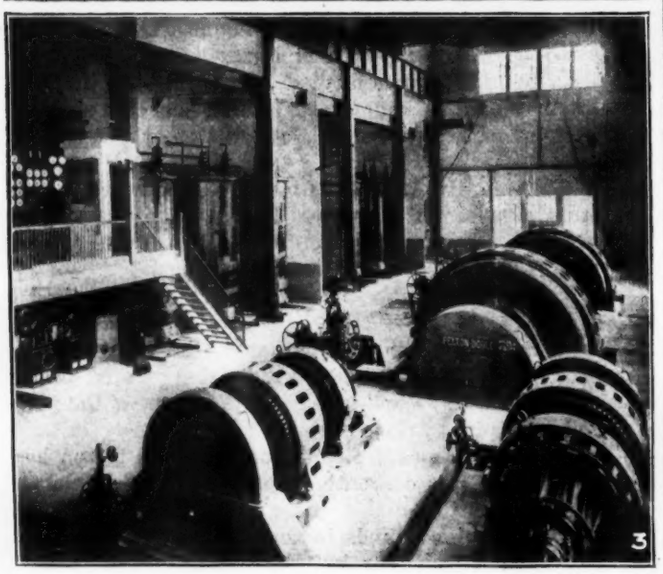
If the engine pounds in the cylinder, the noise may be produced by either late ignition or preignition. If the former, the sound is dull, while early ignition causes a sharp metallic sound. Unless the preignition results in loss of power, it is not detrimental. In fact, usually the highest efficiency is secured while the engine is preigniting lightly.

Some Views of Pacific Gas and Electric Company's Properties, San Francisco, Cal.









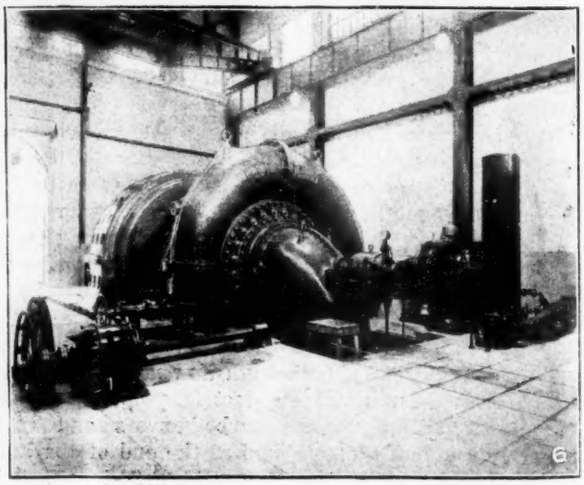


FIG. 1. "PACIFIC SERVICE" FLUME IN BUTTE CREEK CANYON CARRYING WATER FROM DE SABLE POWER HOUSE TO CENTERVILLE POWER HOUSE, EIGHT MILES DOWNSTREAM. FIG. 2. PACIFIC SERVICE STEAM ELECTRIC STATION ON SACRAMENTO RIVER. FIG. 3. INTERIOR DRUM POWER HOUSE. FIG. 4. THE WISE POWER HOUSE, 16,500 HORSEPOWER CAPACITY. FIG. 5. DRUM POWER HOUSE IN BEAR RIVER CANYON, CAPACITY 33,500 HORSEPOWER. FIG. 6. INTERIOR WISE POWER HOUSE

Overhead Arc Welding—Theory and Practice

Overhead Arc Welding Entirely Practical if Operator Understands Principles—Investigation of Failures of Welded Firebox Seams Has Resulted in the Conclusion that the Operators Were Unfamiliar with the Basic Requirements—Theory of Metal Deposition on Overhead Welds Explained—Results Given of Tensile Tests Made on Sections Cut from Overhead Welds

By O. H. ESCHHOLZ
Material and Process Engineer, Westinghouse Electric and Manufacturing Company

FIG. 1. LIQUEFIED GLOBULAR END OF WIRE ELECTRODE

A UNIQUE and important property of the metallic-electrode arc-welding process is the ability to deposit metal at will either on a flat (downward), vertical or overhead surface. Under the extreme condition of overhead deposition, when the force of gravity is opposing metal transfer, greater manipulative skill is required than when gravity partly or completely assists deposition, as in vertical or downward welding. The degree of skill required for overhead welding, however, is not prohibitive when the operator has been properly instructed in the characteristics and manipulation of the arc.

The enlarging field of welding has increased the demand for overhead welds, the most typical of which are encountered in locomotive, ship, tank and building construction. Many such welds are now giving excellent service. Examination of occasional failures reveals, as their primary cause, an improper use and manipulation of welding materials due chiefly to inferior or indifferent operators. In the repair of locomotive fireboxes it has been common practice to autogenously weld the overhead butt joint between the crown and flue sheet. The service records of many such welds clearly demonstrate the adaptability and value of the arc process. Nevertheless, owing partly to the greater skill required and partly to the characteristic exaggerated conception of ability possessed by undeveloped welders, unsatisfactory fusion may result when adequate supervisory control is lacking.

The failure in service of overhead autogenously welded firebox seams may involve a serious life hazard. Investigation of the few failures on record by members of the American Welding Society has resulted in the conclusion that the operators were unfamiliar with the basic requirements for obtaining fusion and preventing slag inclusions. It is evident that partly fused structures heavy with slag content are not welded and will rupture suddenly without appreciable elongation on the application of a small load. To prevent such isolated instances from retarding the normal growth of overhead arc welding, a wider dissemination of knowledge concerning the factors determining weld characteristics, welding procedure and inspection should be encouraged.

Mechanism of Metal Transport

Overhead deposition is chiefly dependent upon arc phenomena overcoming gravitational force acting on the material of the pencil electrode. The facility with which deposition is accomplished is a function of arc current and arc length, as well as choice of electrode diameter and electrode material.

Upon establishing an arc between an overhead surface and a suitable wire electrode, the material at each arc terminal is liquefied. The metal at the positive, or

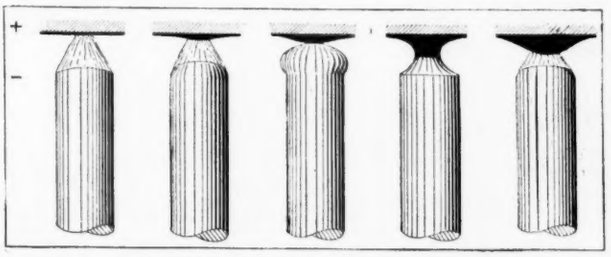
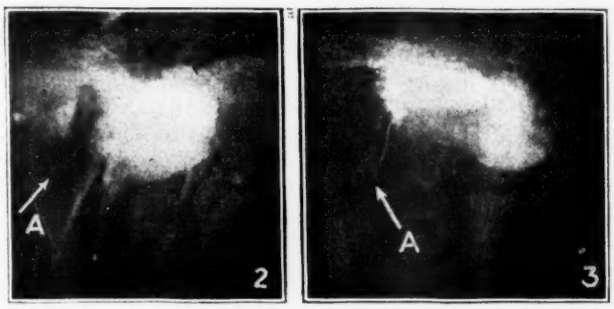


FIG. 4. SEQUENCE OF DEPOSITION PHENOMENA IN OVERHEAD WELDING

plate, terminal forms a pool, while that at the wire, or negative, **terminal develops rapidly into a globule.** Fig. 1 shows the appearance of the surface and section of a globule formed on the electrode end. This globule, however, is too large to facilitate deposition; that shown in the arc photograph, Fig. 2, is more typical of good practice. To convey this globule to the plate, the lifting force must exceed the retaining forces of gravity, cohesion and surface tension at the wire perimeter. Obviously, the problem of transferring the globule may be simplified by decreasing the forces tending to retain it on the electrode end. By producing only small globules, the weight of liquid metal may be held low. As the size varies, within limits, with arc length, the maintenance of a short arc of from $\frac{1}{16}$ in. to $\frac{3}{32}$ in. will therefore insure a controllable globule weight. Other factors determining the magnitude of the total retaining force are the unit surface tension, unit cohesion and the contact area between the liquid globule resting on the solid end of the pencil



FIGS. 2 AND 3. APPEARANCE OF ARC STREAM, DEPOSITED MATERIAL AND ELECTRODE END

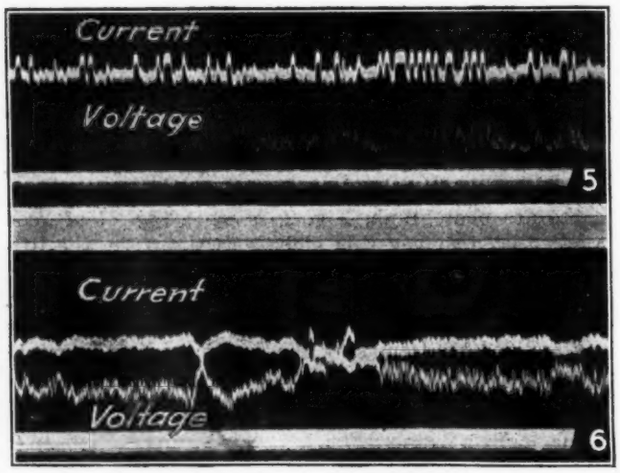
Fig. 2—Shows a short arc and the globular end of the electrode as well as the layer of deposited metal. Fig. 3—Long arc. No deposited metal is evident.

electrode. The surface tension and cohesion between the solid wire and its molten end is decreased by the presence of solid, liquid and gaseous impurities at the boundary. Quantitative information on this subject is not available. Experience, however, has shown that these forces are reduced by the phenomena occurring when small quantities of iron oxide, iron carbide, manganese, etc., and occluded gases are present in the electrode during the deposition process.

The total surface tension and the total cohesive force are proportional to the area of contact between the liquid and solid or plastic metal. It is obvious that these decrease with the diameter of the electrode and also with the total energy developed, and therefore with the arc current. The facility with which the electrode surface becomes "wetted," thereby affecting the contact area, varies with its analysis, melting temperature, physical properties of the surface and the current density. A satisfactory evaluation of the importance of all these factors has not been made, although it is well known that different types of electrodes employed for downward deposition vary greatly in their "wetting" action and therefore in their characteristic retaining force and ease of overhead deposition.

From this analysis it is evident that when the supervisor determines the material, size of electrode and welding current to be used, the only variable affecting the magnitude of the retaining force controllable by the operator is the arc length. Skill in the maintenance of the proper arc length may be readily developed while a check on its continuous employment may be secured by the meter indication of arc voltage or the ringing of a buzzer connected across the arc when the maximum permissible arc length has been exceeded.

The lifting force is, comparatively, a fixed quantity, since the material and thermal characteristics of most

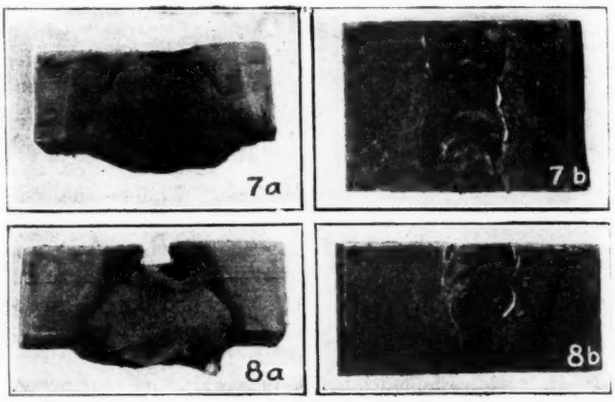


FIGS. 5 AND 6. EFFECT OF HOLDING A SHORT AND A LONG ARC ON VOLTAGE AND CURRENT

overhead joints vary but little. The total lifting force is a function of the surface contour and of the area puddled by the positive crater. It is also dependent upon the "wetting" characteristic, which facilitates the adhesion and spread of the electrode globule on making contact with the puddled surface. The rate at which the plate metal absorbs heat energy from the deposited metal determines the rate of congealing of the electrode metal and therefore is a factor in determining the magnitude of the lifting force. Heating an overhead joint very locally, facilitates starting layer deposition, since it facilitates the initial production on a cold plate of a "wetted" surface to which the globule must be attached by the forces of surface tension and adhesion. However, if the joint temperature is uniformly increased to a high value, deposition will be retarded since the rate of congealing of deposited metal is decreased. The cycle of deposition appears to be as follows:

1. Metal at each terminal is liquefied upon striking an arc.

2. The molten electrode end assumes an approximately spherical form due to the well-known phenomena



FIGS. 7 AND 8. CORRECTLY AND INCORRECTLY FUSED ABUTTING MEMBERS

Fig. 7a—Initial layers of weld completely fused. Fig. 7b—Surface view of Fig. 7a. Fig. 8a—Incomplete fusion of initial layers. Fig. 8b—Surface view of Fig. 8a.

of surface tension causing a fluid material to contract into the smallest volume.

3. This globule enlarges with continued application of energy, until with the aid of electrode manipulation its upper surface is brought into contact with the overhead pool, thereby short-circuiting the arc stream and causing the lifting forces to act upon it.

4. Forces of surface tension and adhesion, at the contact area between the overhead plate and the globule, cause the globule to change its form and spread over the plate surface.

5. As the metal spreads, the area in contact with the plate increases and therefore the lifting forces are also increased, causing an acceleration in metal transfer. These forces act until the globule is lifted off the wire electrode end, when the short-circuit is broken and the arc re-established.

This deposition sequence is shown graphically in Fig. 4. In Figs. 2 and 3 short ($\frac{3}{32}$-in.) and long ($\frac{5}{32}$-in.) arcs are shown respectively. Bare mild-steel electrodes were used for the deposit tests. The globular growth is visible on both electrode ends. However, the short arc employed in Fig. 2 permits, with the electrode manipulation, bringing the surface of the globule readily into contact with the plate during the period when the retaining force is small. To bridge the arc gap shown in Fig. 3, a larger globule is required. The size of this globule produces a retaining force that exceeds the lifting force and thereby prevents metal transfer. With continued application of energy and the maintenance of such a long arc the accumulating liquid metal either drops off the end of the electrode or flows down its side.

In Figs. 5 and 6 are shown instantaneous variations in arc current and arc voltage when holding short and long arcs shown in Figs. 2 and 3. The instant at which

the globular growth short-circuits the arc is identified when the arc-voltage record drops to nearly zero and the arc current attains maximum value. The frequency with which this occurs indicates that approximately 25 globules are being deposited each second. In Fig. 6 the voltage and current records indicate the normal variation in arc length as determined by electrode manipulation and globular growth, but they do not indicate contact between the plate and the electrode as shown in Fig. 5. The deposition rate is therefore nearly zero, only metal being deposited by the condensation of a small amount of metallic vapor. As the amount deposited is small, it is not visible on the plate surface shown in Fig. 3.

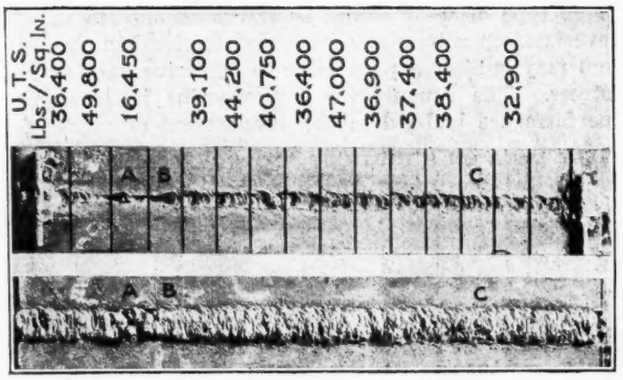


FIG. 9. APPEARANCE OF TOP AND BOTTOM OF OVERHEAD BUTT-WELDED PLATES

For instruction purposes, phenomena of overhead metal deposition may be readily simulated by employing a mercury analogy. This demonstration may consist merely in transferring a globule of mercury, resting in the cupped end of a steel rod, to an overhead amalgamated surface. When contact occurs between the globule and the amalgamated plate, mercury passes to the overhead surface with such speed that it appears to leap from the rod to the plate.

Training of Operators

It is preferable to select candidates for overhead welding from operators who are competent downward welders. The first step in the training of such welders consists in demonstrating and explaining phenomena of metal transfer, the second step, the change in deposition facility with change in arc length, arc current, electrode diameter and electrode material. It will be found that the usual skilled downward welder is quick to appreciate and recognize the bearing of these factors on overhead deposition. Deposition skill should first be developed on a vertical surface, then on a plate inclined 45 deg. and finally on a flat overhead surface with the operator holding in each case, a short arc $\frac{1}{16}$ in. to $\frac{3}{32}$ in. or 18 to 20 volts, $\frac{1}{8}$ in. diameter bare mild-steel gas-free electrodes and an arc current of 100 amperes. The metal should be deposited in continuous layers on a $\frac{1}{2}$-in. thick plate. The employment of a light-weight electrode holder, designed to protect the operator from falling hot metal, as well as to remain cool in service with a minimum cable drag while holding the electrode perpendicular to the surface to be welded, will be found to both expedite and greatly facilitate overhead deposition.

Electrodes vary greatly in their overhead deposition characteristics. Metal may be deposited with some types at the rate of two globules a second; with others this may be as high as thirty a second. The penetration of the deposited metal into the plate appears, however, to decrease somewhat with increase in globular deposition rate. Owing to the facility whereby the surfaces of some types of electrodes become "wetted," the globular retaining forces are so large that overhead deposition is impracticable. In view of these differences in deposition performance the operator should become familiar with the characteristics and manipulation of a variety of bare and covered electrodes available on the market. To obtain fusion, it is necessary to secure penetration, crater depth, minimum overlap, etc., characteristic of downward deposition.

The use of a low current, of the order of 100 amp., produces a slow and easily controllable globular growth and deposition. After the operator succeeds in developing deposition control under this condition, arc current and electrode diameter should be gradually increased to values approximating those employed for downward welding. The operator, however, will then find that an electrode length of only six inches (approximately) will be readily deposited, the deposition of the remainder becoming increasingly difficult owing to the fact that the hot, inclosing convection currents of air and arc gases, as well as the internal energy consumption due to the resistance of the wire, serve to preheat the electrode and cause the melting rate of its terminal to

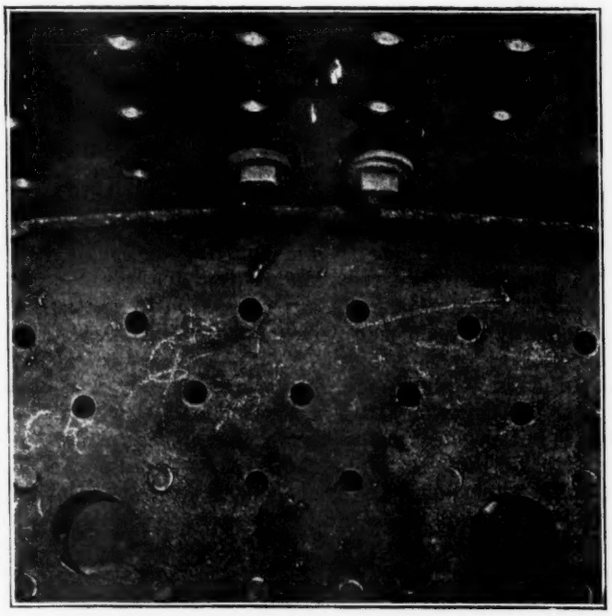


FIG. 10. OVERHEAD BUTT-WELD JOINING LOCOMOTIVE CROWN SHEET TO FLUE SHEET

increase. It has been found that the electrode may be kept comparatively cool, and therefore maintain an approximately constant melting rate throughout the deposition period, by giving it, as well as the arc terminal, either an oscillating or a circular movement. Such a movement disturbs the hot sheath of gas in contact with the electrode and permits the influx of cooling air. By employing this manipulative expedient, it is possible to deposit the metal continuously from 12-in. lengths of $\frac{1}{8}$-in., $\frac{5}{32}$-in. and $\frac{3}{16}$-in. diameter electrodes when employ-

ing arc currents of respectively 125, 150 and 175 amperes.

Overhead welds are commonly butt or lap joints. In designing a structure, preference should be given to the lap joint because it is more easily welded. The overhead butt joint is prepared similarly to the downward butt joint. It is usually scarfed from 60 to 90 deg. and a "free distance" of from $\frac{1}{8}$ in. to $\frac{3}{32}$ in. separates the adjacent sections. To maintain these in place, the

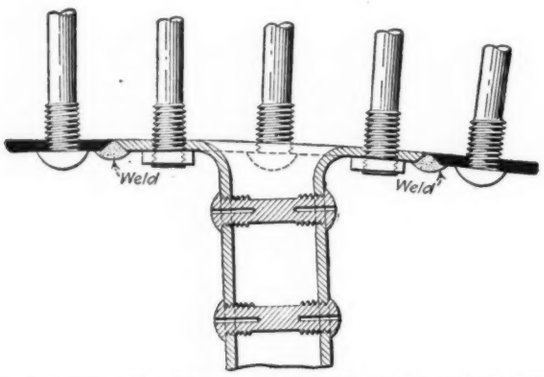


FIG. 11. SECTION THROUGH OVERHEAD WELDED CROWN SHEET AND SIPHON FLANGES, SHOWING POSITION OF WELDS

plates are tacked together at intervals of 2 ft., when the rigid assembly system is used, and the metal deposited in layers by the "step-back" method to avoid excessive heating of the plate and consequent high internal cooling stresses.

The successful welding of an overhead butt joint is chiefly dependent upon the completeness with which the initial layer fuses together the apex of the V. In Figs. 7a and 7b are shown sections through correctly fused abutting members. Figs. 8a and 8b illustrate the characteristic appearance of a section wherein the first layer failed to fuse the abutting plate edges. Such failure may be attributed to the indifference of the operator in controlling arc length and applying deposited metal, too low an arc current, and either too great or too small "a free distance." An inspection of the surface frequently reveals poor workmanship and suggests the cause.

In Figs. 7 and 8 are shown, respectively, the character of fusion obtained in zones *A* and *C* of the overhead butt-welded plates shown in Fig. 9. An examination of these exhibits shows that visual inspection of the joint during preparation and after completion may give a fair indication of the weld properties.

It is now recognized that in downward welding, layer and tier deposition of metal give the most satisfactory joint characteristics. This is due to the fact that each deposit is reheated by the superposed metal and then cools at a slower rate than if exposed fully to the atmosphere. This partial annealing serves to refine the grain and relieve internal cooling stresses. The writer therefore wishes to advocate a similar procedure for overhead welding, particularly as it is now general practice to completely fill the area between scarfed surfaces as the welder progresses along the joint. It is known that this procedure increases internal stresses, decreases ductility and facilitates warping of the structure.

The plates shown in Fig. 9 were welded after the operator had had but two days' practice in overhead deposition. After several days' further practice the same operator butt-welded $\frac{1}{4}$-in. and $\frac{1}{2}$-in. boiler plates overhead, scarfed to 90 deg., employing mild-steel electrodes $\frac{3}{32}$-in. in diameter, and 125 amperes. The results of tensile tests on strips cut from these plates are given in the table. These data show that a conscientious and properly instructed operator will produce overhead welds having characteristics comparable with those made in more favorable positions, and if the basic fusion requirements are observed by even a relatively inexperienced overhead welder, a quite satisfactory weld will be obtained.

In Fig. 10 is shown the usual overhead butt weld joining the crown sheet of a locomotive to the flue sheet. This type of weld should be intrusted only to skillful overhead operators, since a low water level in the boilers may subject a poor joint to excessive heating and stress. The demand for improvement in locomotive performance had led to the development of means for

TEST DATA ON STRIPS CUT FROM OVERHEAD WELDED BOILER PLATE; WELDS UNMACHINED

Test No.	U. T. S. Lb. per Sq. In. ¼-In. Plate	Per Cent. Elon. Inches.	Test No.	U. T. S. Lb. per Sq. In. ½-In. Plate	Per Cent. Elon. Inches.	Test No.	U. T. S. Lb. per Sq. In. ½-In. Plate	Per Cent. Elon. Inches.
1	47,700*	15.0	1	34,600*	7.2	1	40,300*	10
2	40,300	6.8	2	40,300	7.2	2	45,000	10
3	48,800	7.2	3	42,500	7.5	3	44,300	9
4	47,000	7.2	4	39,600	12.5	..	.....	....
5	50,000	8.0	5	40,500	9.1	..	.....	....
6	50,600	3.5	6	38,000	6.8	..	.....	....
7	43,400	8.5	7	45,300	.....	..	.....	....
8	37,000*	7.2	8	34,800*	.....	..	.....	....
Avg.	45,600	7.9		39,450	8.4		43,200	9.7

*Plate ends.

increasing the boiler capacity and efficiency, one scheme is to use thermic siphons extending from the crown sheet down into the firebox. The top flange of these siphons may be joined to the crown sheet by overhead butt welds. In Fig. 11 is shown a section through the crown sheet and siphon flange. The welds are placed midway between parallel rows of staybolts so that the crown stays carry the greater part of the load. The performance of ten locomotives equipped with arc-welded siphons by the Chicago, Rock Island & Pacific R.R. is being followed with great interest by welding engineers.

The time has arrived in our national development when we must have a definite national program in the development of our great engineering problems, all of which cry for some broad-visioned national guidance. We must create a national engineering sense of provision for the nation as a whole. If we are to develop this national sense of engineering and its relations to our great human problems, it must receive the advocacy of such institutions as this. The Federated American Engineering Societies, composed of the various engineering societies, represent the engineers of the United States. It is our duty as citizens to give voice to those critical matters of national policy which our daily contact with this, the fundamentally constructive profession, illuminates to us. Just as our medical associations voice the necessity of safeguards to national health, as the bar associations offer safeguards to our judiciary, so the engineers should exert themselves in our national engineering policies. We have none; but we need some, or the next generation will face a lower instead of a higher standard of living than ours.—*Herbert C. Hoover.*

Refrigeration Study Course—XVII
Applications of Refrigeration—Ice Making

By H. J. MACINTIRE
Professor of Refrigeration, University of Illinois, Urbana, Ill.

PERHAPS at present refrigeration is the least generally understood of engineering subjects. Steam engines and steam turbines are simply means of utilizing the stored energy in steam, becoming kinetic by means of a drop of pressure and by doing work on a piston or a set of moving blades. The gas and oil engine is simply a substitute for the combination steam boiler and steam engine, whereas the air compressor is more or less a gas pump. Electric motors and generators, although complicated, are understood by the liquid will lie stagnant in the pipes like water in service pipes. It can boil and refrigerate *only* when the surrounding brine or air or other fluid is at a greater temperature than the boiling temperature of the ammonia in the pipes at that moment.

In this Study Course it has been shown that the compressor and the high-pressure side are only a means of using the same refrigerant continuously, and that the piston displacement per minute determines the tonnage possible; also that the valves, passages and

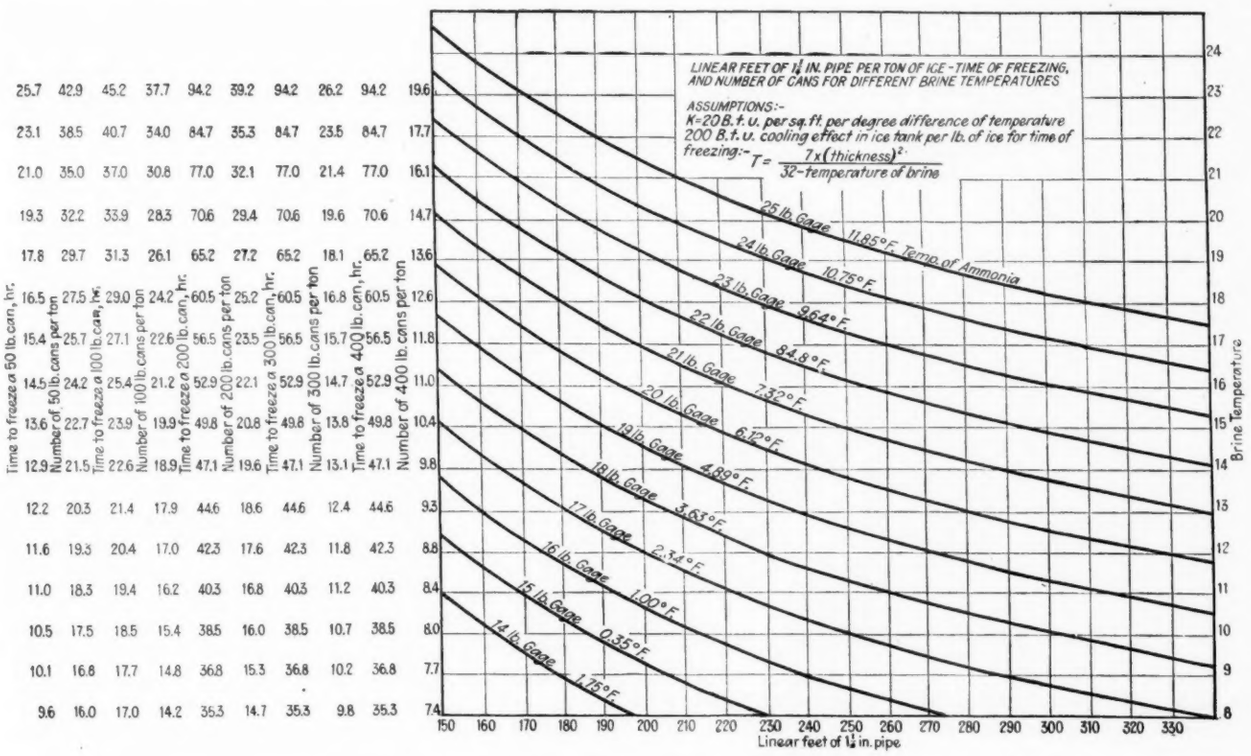

LINEAR FEET OF 1¼ IN. PIPE PER TON OF ICE - TIME OF FREEZING, AND NUMBER OF CANS FOR DIFFERENT BRINE TEMPERATURES
ASSUMPTIONS:-
K=20 B.t.u. per sq. ft. per degree difference of temperature
200 B.t.u. cooling effect in ice tank per lb. of ice for time of freezing:- T = 7x(thickness)² / 32-temperature of brine
25 lb. Gage 11.85°F. Temp. of Ammonia
24 lb. Gage 10.75°F.
23 lb. Gage 9.64°F.
22 lb. Gage 8.48°F.
21 lb. Gage 7.32°F.
20 lb. Gage 6.12°F.
19 lb. Gage 4.89°F.
18 lb. Gage 3.63°F.
17 lb. Gage 2.34°F.
16 lb. Gage 1.00°F.
15 lb. Gage 0.35°F.
14 lb. Gage 1.75°F.
Linear feet of 1¼ in. pipe
Brine Temperature
Time to freeze a 50 lb. can, hr.
Number of 50 lb. cans per ton
Time to freeze a 100 lb. can, hr.
Number of 100 lb. cans per ton
Time to freeze a 200 lb. can, hr.
Number of 200 lb. cans per ton
Time to freeze a 300 lb. can, hr.
Number of 300 lb. cans per ton
Time to freeze a 400 lb. can, hr.
Number of 400 lb. cans per ton

FIG. 1. TIME TO FREEZE WATER TO ICE UNDER VARIOUS COMMERCIAL CONDITIONS

the simple fact of their becoming commonplace through universal application. And yet the refrigerating system still acquires and maintains its frost-covered pipe lines because ammonia "expands" in the pipe like steam in a turbine; at least that is the popular explanation.

Engineers must get out of the habit of speaking of "expansion of ammonia" and must consider the action as boiling. In the steam heating system steam at from 1 to 10 or 15 lb. is admitted to the steam coils or radiators. It gives up some of its heat to its surroundings, the air, and in so doing it is condensed. The steam radiators are a sort of condenser. Likewise the refrigerating coil is a boiler, for the liquid is boiled into a gas, and as a gas or vapor it passes out of the coil and into the compressor again. If the boiling temperature of the ammonia in the refrigerating coils is too high, as when the suction pressure rises too much, headers affect the economy of operation. Likewise the condenser and the condensing water affect the head pressure, which should be as low as possible, everything considered, as more *work* is done during compression and the volumetric efficiency is decreased (the capacity of the compressor is lowered) by an increase of condenser pressure. In a similar manner the suction pressure must be kept as high as practical because the work done in the compressor, the volumetric efficiency, and the displacement of the piston per unit of refrigeration are affected adversely by a suction pressure which is lower than that which is really required.

Therefore, there has been a discussion of the compressor, the condenser, stage compression, ammonia, fittings, as well as the brine system, refrigerants and condensing water. So far in this course greatest emphasis has been given to the compressor room.

The applications of refrigeration are independent of the form of compressor or condenser and affect only the low-pressure side. Even the use of brine does not affect particularly the engine-room equipment except in the required use of a brine cooler and the necessary brine pumps. Of course the suction pressure for indirect refrigeration by the use of brine has to be lower than when direct expansion in the expansion coils is used. This is because the ammonia cools the brine, and then the brine cools the air or other goods requiring refrigeration. This makes a *double* temperature difference, or heat transfer and it has been shown that for maximum efficiency of operation the suction pressure (and therefore the boiling temperature of the ammonia) should be as high as is practically

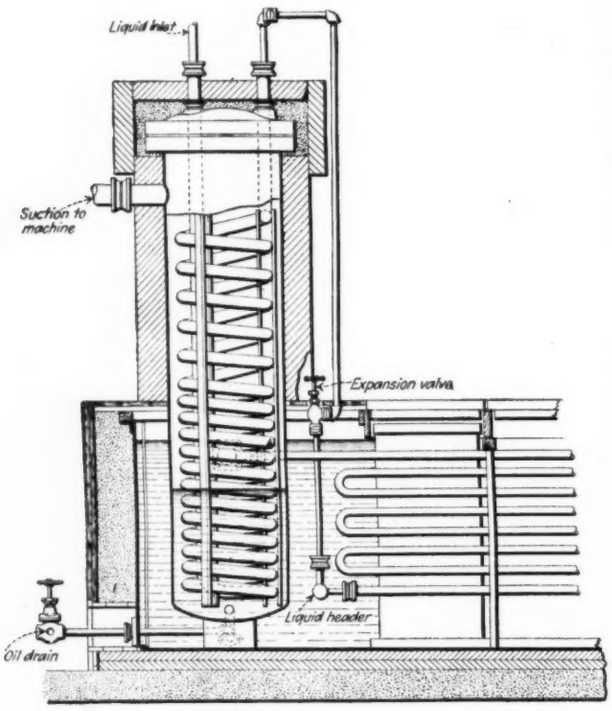


FIG. 2. AMMONIA PRECOOLER

possible. The applications of refrigeration, then, are different in the manner of using the cooling coils (either brine or ammonia) and the details of the equipment which goes with them. It will be the purpose of this and the next article to show how these applications affect the details of the equipment.

The largest applications of refrigeration at present in this country are ice making, cold-storage and packing house refrigeration, pasteurizing and other dairy work, and, finally, refrigeration in certain chemical industries. These will be taken up more or less in detail.

Application of Refrigeration to Ice Making

Ice making by means of mechanical cooling is at present one of the largest applications of refrigeration. It is increasing in its use, even in the regions where a natural ice crop is convenient and cheap, because it usually looks better and may be manufactured conveniently near the place where it will be used. On account of its bulk and rapid melting or shrinkage, it cannot usually be transported very far without the cost increasing beyond the economic point.

At first ice was made by freezing on one side of a flat plate immersed in a tank of water until 8 to 12 in. thickness of ice was formed, the plate having a means of feeding in liquid ammonia and allowing the gas to return to the compressor in the usual manner. This is a raw-water system, which is highly satisfactory and is still used with success. The plate ice system is seldom installed now because of the greater first cost required, greater headroom necessary and lower back pressure carried on the machine. Large cakes of ice are frozen, from 3 to 5 tons, and this requires heavy handling apparatus, a suitable saw and table for sawing into convenient (300-lb.) cakes. The time of freezing increases greatly with the thickness of the ice made and usually requires six days. All water has air in solution, the amount depending on the temperature of the water and other conditions. If this water is frozen quietly, the air will be pocketed in the ice and the ice formed will have the appearance of marble, and is called "tombstone ice." It may be as valuable as clear ice so far as cooling effect is concerned, but it does not look as well. In consequence water to be frozen into plate ice is agitated by means of air under a few pounds pressure which is allowed to bubble up the freezing surface of the ice and thereby prevent the air of solution adhering to the ice surface.

The Can Ice Method

Parallel with the development of plate-ice systems came the *can ice* method, using distilled water. If steam is condensed (and reboiled slightly while exposed to the atmosphere) then cooled without exposure to the air, it may be frozen into a cake without producing a core, and becomes almost as clear as crystal. In the early days of refrigeration, and at present where the water is very heavy in salts, the use of distilled water for ice making was popular. Being distilled and reboiled it was considered hygienic and therefore appealed to the household retail trade.

In the can system of ice making, a galvanized iron can of rectangular cross-section but of slight taper toward the bottom is filled with water and lowered into a brine tank. The brine is usually maintained at about 14 deg. F. by means of ammonia expansion piping inside the tank in stands on two sides of the can, or is cooled in a brine cooler either inside the tank or entirely separate from the tank. The brine is circulated by means of propellers, with either horizontal or vertical shafts. These propellers are designed in a similar manner to a ship's propeller and are used to keep up a rapid circulation of the brine in and about the cans, thereby maintaining a uniform temperature of brine and also increasing the coefficient of heat transmission through the can to the ice and water. Heat is abstracted from the water, and the ice is formed rapidly, at first all around the surface of the can and then progressively slower as the center is approached. Evidently, with good agitation, the time of freezing of a certain size can depends on the brine temperature and the cross-section of the can. The brine temperature depends on the boiling temperature of the ammonia (the suction pressure) and the linear feet of direct expansion piping in the tank. All these variables are given in the diagram, Fig. 1. This diagram is recommended by the author for conservative practice, but the tonnage of a plant designed by the diagram should be greater if care is taken with the operation details and a flooded system is installed.

The flooded system for can-ice plants has been successful. The essential feature of this system is a device to precool the liquid ammonia to a temperature equal to that of the boiling ammonia in the coils (corresponding to the suction pressure). The coils may be fed by gravity or by the usual expansion valve (Fig. 2). In

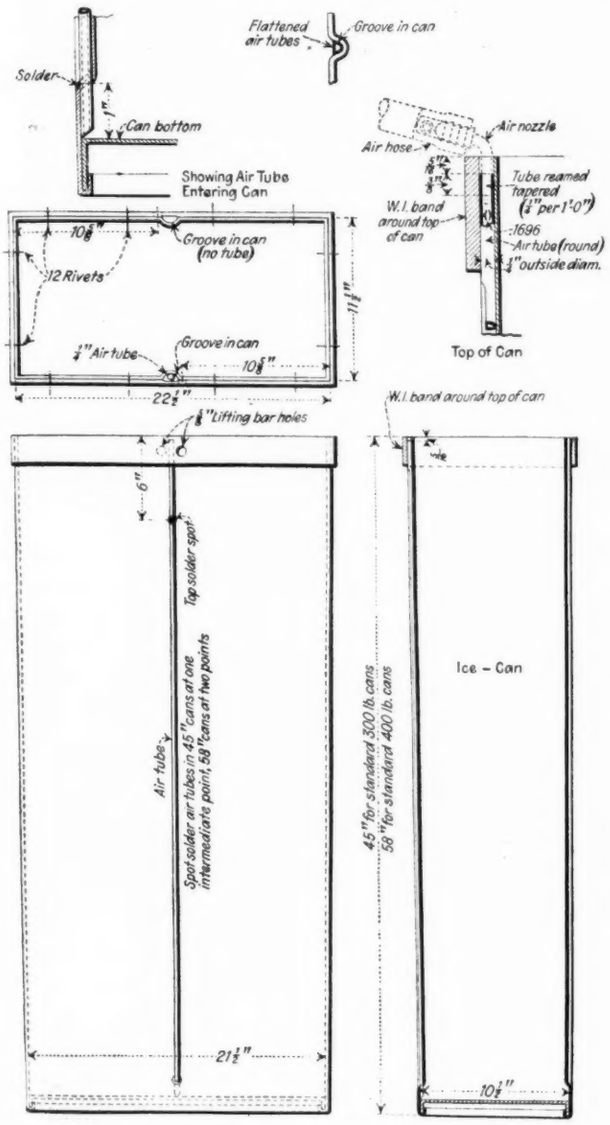


FIG. 3. SECTIONS OF COMMERCIAL ICE CANS

either case the coils are much more nearly filled with liquid ammonia and the heat conduction from the brine to the liquid ammonia is better than would be the case with the old system. The flooded method does not give more refrigeration per pound of ammonia; it simply reduces piping in the tank.

Raw-Water Can Ice

One of the great advances in refrigeration during the last decade has been in the methods of ice making. The universal use of electric power, generated by steam as well as hydro-plants, has created a demand for an ice plant which has no ready means of securing steam for distilled water. Also the mounting cost of fuel, notwithstanding the reduced steam consumption of the steam engine, as well as the application of Diesel and semi-Diesel engines as compressor drives, has resulted in a great demand for a raw-water can-ice system which will provide a clear crystal-like cake of ice.

As already mentioned, agitators of raw water during freezing will provide a crystal plate ice, and the same is true to a certain extent in the case of can ice. However, a residue is left in the can (a core) which is likely to contain all the impurities of the can of water. Very good water (free from suspended and dissolved solids) need be agitated only by air under pressure until it is nearly completely frozen, but water containing much solids not removed by previous treatment must have a core-pump. This pump will remove the remaining small part of the original canful of water. The resulting cavity may then be refilled with distilled water.

The methods of providing agitation and securing clear ice are numerous. One way is to provide drop pipes into the center of the can and to allow air under 2 to 3 lb. pressure to bubble up. This is one of the simplest and cheapest first-cost constructions, but requires constant care on the part of the operator as the drop pipe will freeze into the ice if it is not removed before the cake is entirely frozen. To prevent this annoyance, the high-pressure system is used, the air being compressed to 25 lb. or more and precooled before being allowed to get to the can so as to remove as much of the moisture content as possible. Fig. 3 shows one system where the pipe inside the can is soldered to one corner and becomes an integral part of the ice can. The main objection to this arrangement is the difficulty of removing from the air a sufficient quantity of its water content to prevent the formation of frost at the needle valve and in the feed pipe, thus choking up the air supply to the can and preventing agitation. Also it is necessary to have 100 per cent continuous operation, as otherwise the feed valve will freeze solid and (without agitation) will form opaque ice.

There are numerous other systems of more or less merit. The main points in raw-water ice are all the same, however. "Water good enough to drink is good enough to make ice," and clear ice must be agitated during freezing.

No. 300-Lb. Cans per Ton Condenser Pressure,	Horsepower Input to Motor, Belted Compressor, with Varying Condenser Pressures				Kilowatt-Hours per Ton Ice, for Compressor Only, with Varying Condenser Pressures			
	145 lb.	165 lb.	185 lb.	205 lb.	145 lb.	165 lb.	185 lb	205 lb.
14	2.08	2.38	2.59	2.84	38.8	43.8	48.3	52.9
15	2.01	2.28	2.56	2.78	37.5	42.6	47.8	51.8
16	1.96	2.21	2.48	2.74	36.5	41.2	46.3	51.1
17	1.94	2.18	2.43	2.68	36.2	40.6	45.3	49.9

In all cases it is assumed that water at a temperature of 70 deg. F. will enter the storage tank for freezing purposes.

The Argentine government has inaugurated a survey preliminary to the construction of a power plant at the Iguazu Falls, in the northeastern corner of the country. It is reported that an international power plant, with a capacity of 150,000 hp. will be erected jointly by the governments of Argentina, Uruguay and Brazil. At present La Compania Hidro-electrica de Tucuman (English) is the only power plant established in Argentina. La Empresa de Luz y Fuerza (German) has a concession for the construction of a power plant at Mendoza. Work on this plant was begun several years ago, but was indefinitely suspended because of a dispute over the concession. The municipality of Mendoza is to construct a power station at the Falls of the Rio Blanco.

Operation and Adjustment of Turbine Machinery-XI
Main Bearings and Their Lubrication

By EUSTIS H. THOMPSON
Consulting Engineer, Baltimore, Maryland

WHEN a turbine is in proper mechanical condition, a main bearing should operate well with a total net clearance of 0.002 to 0.003 in. above the shaft no matter how large the diameter. Of course the clearance of a shaft, in a large bearing particularly, must be great enough to allow for proper lubrication when at running heat. In practice the lower half of the liner is fitted close to the shaft, while the cap has an appreciable clearance which varies from

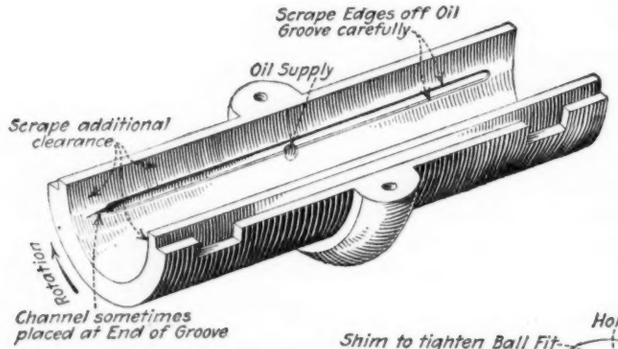


FIG. 1. LOWER HALF OF BEARING SHELL

0.0005 to 0.002 in. per inch of diameter. The weight holds the shaft in the lower part under normal conditions so that the top of the liner is never actually touched by the shaft except when unusual vibration occurs. The cap is necessary for the proper distribution of the oil film and prevents oil from leaking excessively out of the ends of the bearings. In large turbines the cap is often bored out over most of its area so that several ridges are left to touch the shaft and the clearances in such cases are usually the greatest found.

In scraping a bearing, the high spots which are brightened by contact with the shaft should be removed. Be careful that the metal is taken away at the edge of the oil groove where the oil leaves to follow the shaft, so that the oil film will not be restricted in any place. It is customary to scrape a clearance of 0.002 to 0.004 in. on each side of the liner to help in distributing the oil film. (See Fig. 1).

Oil grooves in bearings equipped with oil rings only are for the purpose of collecting the oil and distributing it. A straight oil groove is employed by some manufacturers, while others prefer a curved groove or perhaps two such grooves crossing each other. Where oil is forced to the bearing, the oil groove is straight and should be placed about halfway from the bottom to the middle of the liner on the side in the direction of rotation. When placed in this position, the action of the shaft carries the oil in the direction of flow so that there is a slight tendency to suck the oil supplied. When the groove is on the side against rotation, the oil film is discharged directly into the groove and there is a tendency to force it down the pipe. Turbines have been built with this arrangement and were found to operate better with a check valve in the oil pipe to prevent back flow under abnormal circumstances.

A word of caution is well here. Turbines run at such high speeds that obstructions in oil passages are serious.

The oil groove, Fig. 1, should not extend all the way to the end of the liner, but should stop about one-quarter inch more or less from each end. This confines the oil so that the pressure is available to produce the proper oil film. It is generally considered good practice to make a small channel from the end of the groove to the end of the bearing. This provides an oil film for the area outside of the groove itself and also permits a larger flow of oil, which has an appreciable effect in keeping the bearing cooler. Always examine the oil groove and be ready to scrape both the leading and trailing edges in case high spots appear, this to insure a good oil film. Turbine bearings are usually made of a hard nickel babbitt. In case of an emergency, where it is difficult to purchase proper metal, it can be secured

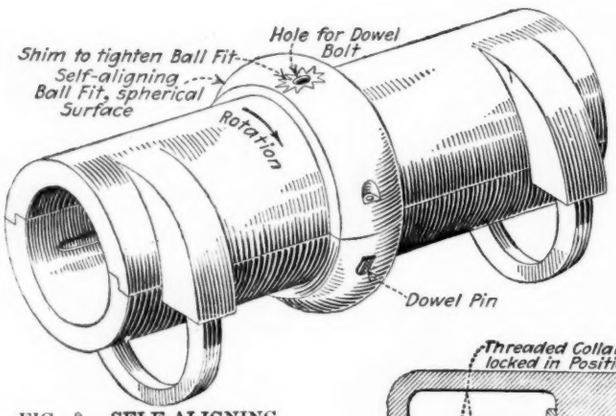


FIG. 2. SELF-ALIGNING BEARING SHELL

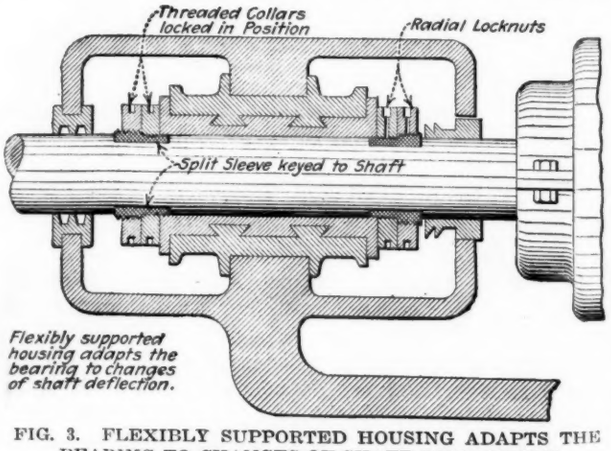

Threaded Collars locked in Position
Radial Locknuts
Split Sleeve keyed to Shaft
Flexibly supported housing adapts the bearing to changes of shaft deflection.

FIG. 3. FLEXIBLY SUPPORTED HOUSING ADAPTS THE BEARING TO CHANGES OF SHAFT DEFLECTION

from street-railway repair shops. High-speed turbine bearings that the writer has measured indicate a total wear of 0.0005 to 0.001 in. per year. At this rate a bearing should last from six to twenty years, depending on the type and design of the machine. Wear in the bottom liner eventually results in one or more of the following effects: General misalignment of machine; shoulders along the oil groove which cuts off lubrication and

causes heating; oil deflector rings touching stationary parts; revolving collars in thrust bearings touching parts of liners; other points of contact between moving and stationary parts; high spots forming on the surface and causing heating; hard parts of the babbitt wearing the shaft irregularly; excessive clearance in the bearing cap causing the oil to be thrown out from a bearing. It seems that high-speed bearings which are often

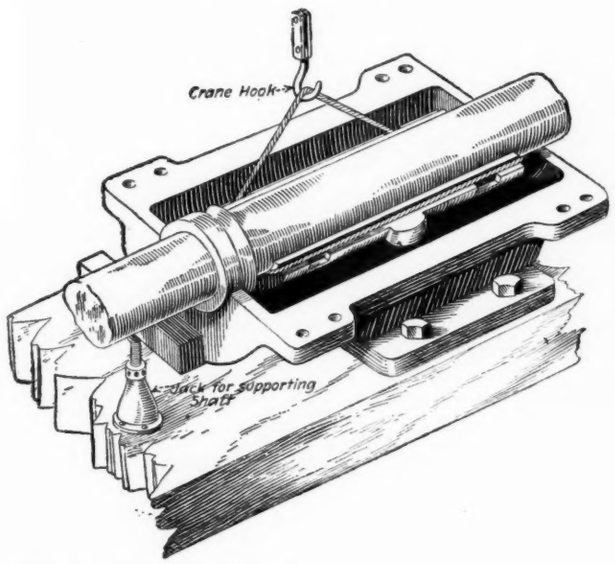


FIG. 4. TURNING OUT A HEAVY LOWER LINER BY USING A CRANE

subject to temperatures continually at the boiling point wear almost unappreciably. In a reciprocating engine the lost motion must be continually guarded against, but in turbine machinery this factor is a minor trouble. Self-aligning bearings, Fig. 2, should be tightened so that they can be moved with a lever two to four feet long. If the self-aligning fit is too tight, the bearing will not adjust itself to the shaft position so that in some cases heating or vibration will result. If too loose it will not usually cause any particular trouble under normal conditions; in many cases a slight vibration and pounding noise develop at this point.

When the ball is too loose, it is customary to tighten this up by placing a small shim on top of the ball, Fig. 2, so that the bearing cap will pinch it to the desired amount. It is convenient to beat out a piece of fuse wire and place this where the shim is required and pinch it by placing the cap in place. The thickness of the lead can be measured with a thickness gage and a shim of the same thickness installed.

Turbine bearings are not always self-aligning, as in some cases the bearing housings are sufficiently flexible to take up the difference in alignment. (See Figs. 2 and 3).

Turbine bearings can be disassembled by removing the upper half and then lifting the shaft about 0.010 in. above the lower half and supporting it in this position while the lower half is rolled over the shaft and then lifted off, as shown in Fig. 4.

Be sure that all water and oil pipes which screw into the liner are removed before attempting this job.

Thrust bearings used by various manufacturers consist of roller bearings, friction collars, ball bearings, marine-type thrusts, piston-type thrust bearings and step bearings.

Machines usually employ a mechanical method (one shown in Fig. 5), for changing the position of the shaft, enabling it to be shifted in an axial direction to properly adjust the blade axial clearances. Other types of thrust bearings require to be disassembled more or less to adjust the position of the shaft. Figs. 3 and 6 are examples.

To adjust the former type of bearing, as Fig. 5, it is safer to keep the machine revolving at a slow rate of speed while the shaft is being shifted in an axial direction so that in case a revolving part should contact with a stationary part, it will be immediately made apparent by a rubbing noise. It is convenient to locate the proper shaft setting by shifting the rotor in one direction until rubbing first begins and then setting permanently in the middle of this travel. Finally, this adjustment should be made immediately after running the turbine at normal speed. When thrust bearings are at normal temperatures, they should run with a clearance of 0.002 in. for each revolving element that bears against a stationary element. Ordinary thrust bearings are given a clearance of approximately 0.001 in. per inch of length between the ends of the thrust. In practice, it follows that too much clearance will allow the shaft to work backward and forward in an axial direction, which can be seen plainly. In extreme cases rubbing occurs. Too little clearance will cause heating or vibration and, in extreme cases, damage to the bearing. Plenty of clearance is desirable.

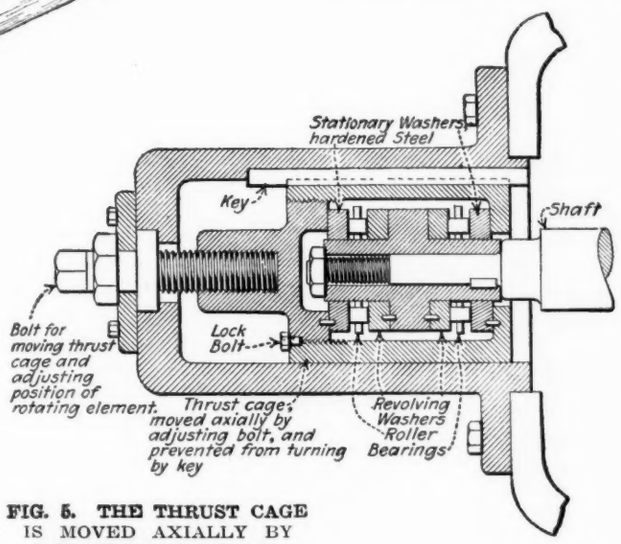

Stationary Washers hardened Steel
Key
Shaft
Bolt for moving thrust cage and adjusting position of rotating element.
Lock Bolt
Thrust cage moved axially by adjusting bolt, and prevented from turning by key
Revolving Washers
Roller Bearings

FIG. 5. THE THRUST CAGE IS MOVED AXIALLY BY THE ADJUSTING BOLTS AND PREVENTED FROM TURNING BY A KEY

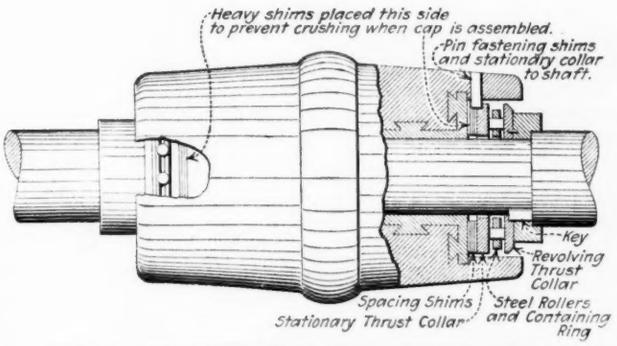

Heavy shims placed this side to prevent crushing when cap is assembled.
Pin fastening shims and stationary collar to shaft.
Key
Revolving Thrust Collar
Spacing Shims
Steel Rollers and Containing Ring
Stationary Thrust Collar

FIG. 6. SECTIONAL VIEW OF A THRUST COLLAR

Ball bearings can be readily assembled by using heavy grease to hold the balls in place. Collar thrusts using babbitt or other bearing material are not difficult to assemble except where shims are used for settling the shaft. These shims are often necessarily very thin, but space is provided in most cases so that a heavy shim of about ½ in. can be placed where the top cap will contact with it in being assembled. A great deal of skill is used in assembling such bearings, and small shims are likely to get misplaced if they are put where the cap will slide on them.

Marine-type thrust bearings are too well known to require special comment here. Piston-type thrust bearings are required to balance the thrust caused by the reaction-type turbines.

Thrust bearings for governors consist of ball races or roller bearings. The principal operating feature is to keep the clearance as small as possible to prevent bad effects in the operation of the governor. Bearings are sometimes made with removable shims for adjusting this clearance. A total clearance of 0.001 to 0.002 in. is usual.

Forty Years of Boiler Explosions

The *Locomotive*, the house organ of the Hartford Steam Boiler Inspection and Insurance Co., contains in its October issue a summary of that company's statistics on boiler explosions that have taken place in the last forty years. The total number of explosions covered is 14,281, in which 10,638 lives were lost and 17,085 persons injured. These figures are not, of course, complete, especially in regard to the number of boilers in use, for no means are available of securing complete records of boilers throughout the country. They may, however, be taken as fairly representative and indicative in a general way of conclusions that would be drawn from a more comprehensive survey.

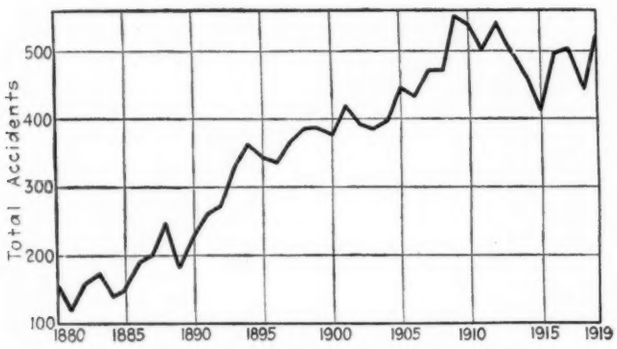


FIG. 1. TOTAL EXPLOSIONS PER YEAR

The figures comprising this summary have been put into graphic form, as in this way their significance is more readily grasped. It should be remembered, however, that charts of this nature must be taken in a very general way. That is, the "saw-teeth," or sharp, extreme changes, are not in themselves of much importance. The general trend of the lines, however, shows more clearly than figures possibly can, just what the situation is.

Fig. 1 shows the rise in the number of explosions per year since 1880. This chart must be considered in the light of the obvious fact that the number of boilers in use has increased steadily; but whether that increase has been less than, equal to, or greater than the increase in the number of accidents cannot well be determined. However, it will be noticed that from 1909 on, a slight and widely varying, yet decisive drop is apparent; and it scarcely seems possible that the number of boilers in use since 1909 could have decreased or even remained constant. That it has, on the other hand, increased, is a reasonable assumption. This of course leads directly to the conclusion that the ratio of the number of accidents to the number of boilers in use has decreased since 1909.

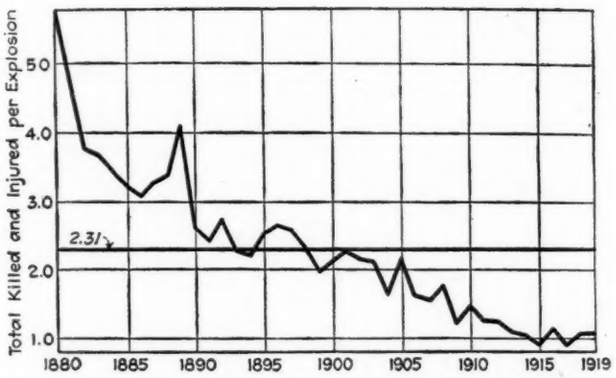


FIG. 2. TOTAL KILLED AND INJURED PER EXPLOSION

Fig. 2 shows a very marked decline in the number of persons killed and injured per explosion. The line marked 2.31 represents the average of the totals for each year. It can be seen that whereas in 1880 more than five persons were killed or injured in each accident, this figure came down to about one in 1919. This curve is of especial interest because of its very pronounced downward trend and because of possible speculation as to its cause.

Fig. 3 represents the changes in the ratio between those killed and those injured in each explosion. While this curve does not fall so rapidly as that in Fig. 2, still it does drop appreciably. It shows that at first there were almost as many killed as injured, and that now the killed are about half of those injured.

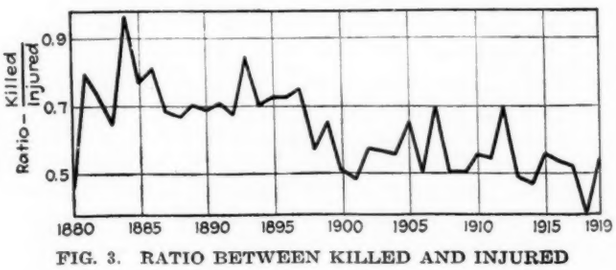


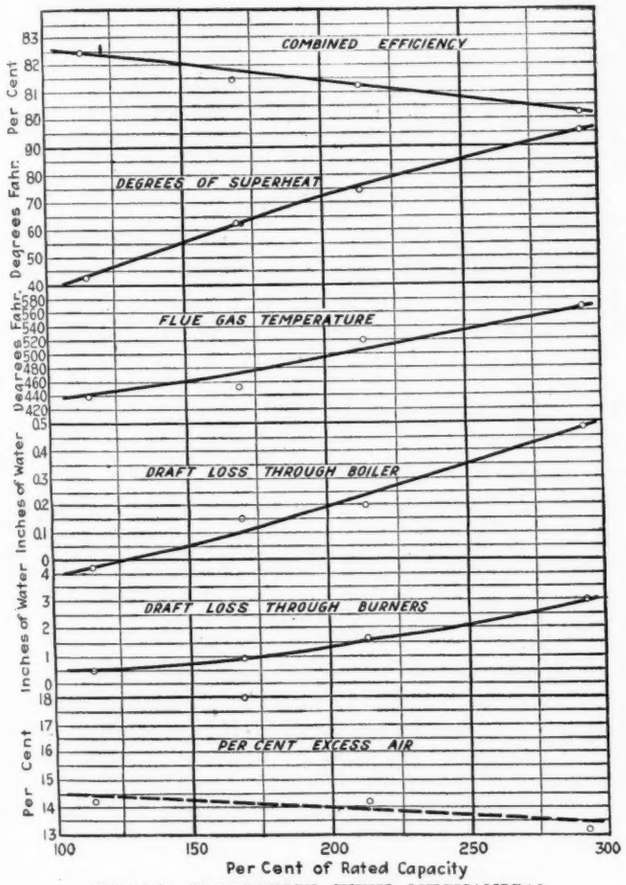
FIG. 3. RATIO BETWEEN KILLED AND INJURED

Taken as a whole, these facts are rather gratifying than otherwise. Though they are incomplete, they indicate with a fair degree of certainty a trend in the right direction. The apparent decrease in explosions relative to the number of boilers in use, the reduction of casualties per explosion and the smaller proportion of fatalities point to increasing care in the construction and operation of boilers.

Unusual Efficiency in Oil-Fired Boiler

A series of tests on a mechanical oil burner manufactured by the Babcock & Wilcox Co. were conducted by the Stone & Webster Corporation at the Riverside plant of the Savannah, Ga., Electric Co. The results of these tests are discussed in the Stone & Webster *Journal*, from which the curves shown in Fig. 1 have been taken.

The oil burner is of an entirely new design, being purely mechanical in action. No steam or air is used in atomizing the oil; this action is secured by the shape of the fluted cone tip. The burner is set in the furnace wall at the center of an air register, which is designed



BOILER EFFICIENCY WITH MECHANICAL FUEL-OIL BURNER

to impart a whirling action to the air. The air is supplied under pressure, and calibrations have been made to determine the proper oil pressure for each reading of the air-blast gage. The regulation of the oil spray is, consequently, very easily secured; the fireman need only set the oil pressure to conform to the air blast being carried.

The results of the efficiency tests appear in the illustration. No other plant, so far as known, has secured over 80 per cent efficiency at 300 per cent rating. The efficiencies shown are gross values, no deduction having been made for steam to operate the air blower and oil pump. The exhaust of these units is used to heat the boiler-feed water; the difference between gross and net efficiency is, then, very small. One interesting feature is the decrease in excess air with the lower ratings and higher efficiency.

Steam-Turbine and Diesel Operating Costs

In the several European countries central stations and industrial power plants of large size have installed Diesel engines in preference to steam turbines. Without doubt, the high price of coal and the availability of coal tar for the Diesels have largely dictated the choice made. In the United States, while many large gas engines have been installed in past years, the oil engines, when installed in other than small plants, have been chosen, as a rule, on account of cheap oil, lack of water or considerations other than actual comparative efficiencies.

It is unfortunate that more information is not available as to costs of steam-turbine plants and Diesel plants when operating under like conditions. In the table shown below are given the comparative power-plant operating costs of a 600-kva. steam turbine and a 365-hp. Diesel engine. These two units are installed in an industrial power plant, receiving the same attention and operating under like conditions. Both units are driving generators, enabling the output of each to be accurately determined. The steam for the turbine is supplied by water-tube boilers using oil as fuel. Since the boiler efficiency is generally higher with oil than with coal, the B.t.u. per kilowatt-hour is lower than the result obtained with coal.

The Diesel exhaust line is equipped with a heater that heats the boiler-feed water and the Diesel should have been credited with the heat so added. The turbine circulating-water and air pumps are motor-driven, and no deduction has been made for this power. In all respects the turbine has been favored.

In the figures given, the labor per kilowatt-hour with the Diesel is from two to six times as high as with the turbine. This is due solely to the small output of the Diesel; an engine twice as large would have the labor cost reduced 50 per cent. The lubricating charges contradict the prevailing belief that the Diesel uses excessive amounts. That the oil engine is particularly adapted to central-station work is shown by the variation in efficiency with change in load. A 25 per cent change of load in the turbine produced a 20 per cent change in efficiency; on the other hand, the Diesel shows a 100 per cent load variation with but 3 per cent change in the efficiency. It should be remarked that the average load on the steam turbine was 568 kw., while the engine's load averaged only 200 kw., or approximately half-load. If the Diesel had been fully loaded the labor and lubricating oil per kilowatt-hour would have been reduced by at least 6 mills.

COMPARATIVE OPERATING COSTS OF DIESEL AND STEAM TURBINE

	Turbine					Diesel				
Week (132 hr.)	1	2	3	4	5	1	2	3	4	5
Kw.-hr. output	58,210	66,050	42,359	64,025	74,925	10,590	25,725	15,680	21,215	24,240
Fuel oil, gal.	23,455	25,950	19,389	24,474	26,836	1,026	2,413	1,524	2,047	2,363
Kw.-hr. per gal.	2.48	2.55	2.23	2.61	2.79	10.3	10.6	10.2	10.3	10.2
B.t.u. per kw.-hr.	51,320	50,000	57,200	48,800	45,300	12,370	12,000	12,300	123,700	12,300
Fuel per kw.-hr., mills	14.1	13.7	15.7	13.4	12.9	3.4	3.3	3.4	3.4	3.4
Lub. oil per kw.-hr., mills	0.1	0.1	0.2	0.15	0.15	0.2	0.1	0.15	0.1	0.11
Labor per kw.-hr., mills	2.4	2.2	3.4	2.2	2.00	13.0	5.6	9.30	6.6	5.6
Operating cost per kw.-hr., mills	18.6	16.0	19.3	17.75	15.05	16.6	9.0	12.85	10.1	9.11

Production of Gasoline

GASOLINE, at one time a byproduct of the refining industry incident to the production of kerosene, has advanced to a stage where it is the most important product obtained from petroleum. In quantity it now represents more than one-fourth the volume of all products obtained from petroleum and in value is practically equal to the total value of all other products. The 1919 refinery production of gasoline and naphtha (3,957,857,097 gal.), if collected at one point, would fill a storage tank one mile in diameter and twenty-five feet high, or if moved in standard tank cars of 8,000 gal. capacity would require a train more than 3,500 miles in length. On Jan. 1, 1920, there were registered in this country approximately 7,500,000 automobiles and trucks having an estimated value of more than $5,000,000,000, which were almost entirely dependent on gasoline as a source of motive power. This estimate does not take into consideration the value of the large number of stationary, marine and airplane engines that use gasoline as fuel.

The economic importance of gasoline is at present more generally realized than ever before owing to the fact that the domestic supply threatens to become exhausted within a relatively short time and no satisfactory substitutes to replace it have been developed on a sufficiently large scale. One of the largest industries in the country, the automobile industry, has been built up on the belief that there would always be available sufficient quantities of fuel for its product, and the future growth of that industry is entirely dependent on the increased production of motor fuel. It is evident, therefore, that extended efforts must be made to increase the production of gasoline, and since the supply of raw material from which it is made is limited, these efforts must be along the line of increased efficiency in the refining of crude petroleum and in the elimination of waste in utilization of gasoline.

This is the first of a series of articles on gasoline and is published by permission of the Director of the Bureau of Mines. The material for these articles has in large measure been taken from the manuscript of a bulletin on "Commercial Gasoline," by H. H. Hill and E. W. Dean, which will be published at a later date as Bureau of Mines Bulletin No. 191.

Refinery Production of Gasoline

The only available figures which show the refinery production of gasoline for the years prior to 1916 are those given by the Census Bureau in the census of manufacturers, which is taken every five years; since this time the Bureau of Mines has received monthly reports from practically all the refineries. The amount of crude run to the refineries and the refinery production of gasoline, as given by Census Bureau and Bureau of Mines data, is shown by the figures in Table I.

TABLE I. SHOWING REFINERY PRODUCTION OF GASOLINE FOR PERIOD OF SIXTEEN YEARS, 1904 TO 1919, INCLUSIVE

Year	Crude Run to Refineries, Bbl.	Production of Gasoline, Bbl.	Yield of Gasoline — Per Cent	Yield of Gasoline — Gals. of Gasoline per Bbl. of Crude Run
1904	66,982,862	6,920,000	10.3	4.3
1909	120,775,439	12,900,000	10.7	4.5
1914	191,262,724	34,915,000	18.3	7.7
1916	246,992,015	49,020,967	19.8	8.3
1917	315,131,681	67,870,153	21.6	9.1
1918	326,024,630	85,007,451	26.1	11.0
1919	361,520,153	94,234,693	26.1	11.0

Since the statistics make no distinction between gasoline and naphthas, the figures on gasoline production used throughout this paper include the production of naphthas and other petroleum distillates more volatile than kerosene. The production of naphthas is, however, relatively small when compared to total gasoline production.

The figures for refinery production of gasoline include that manufactured by cracking processes, but do not include any of the gasoline recovered from natural gas, with the exception of that portion of the casinghead gasoline production which goes to the refineries and is there blended with other gasoline. In 1919 the amount of casinghead gasoline used by the refineries was given as 2,956,781 bbl., which is probably less than 40 per cent of the total production of that product.

The distillation of crude petroleum is by far the most important source of gasoline. Although a large percentage of the gasoline as now marketed is a blended product, approximately 80 per cent of the total gasoline produced is manufactured by the "straight refining" process. In order to determine the amount of gasoline obtained from the distillation of crude petroleum, it is necessary to subtract from the figures on refinery production, as given in Table I, the amount of gasoline produced by cracking processes and the amount of casinghead gasoline that was blended at the refineries. In 1919 this difference amounted to approximately 76,000,000 bbl. This, of course, includes the production of naphthas, as the reports received by the Bureau of Mines do not make a distinction between gasoline and naphtha.

Gasoline from Natural Gas

A considerable proportion of gasoline is now obtained from natural gas by compression and absorption processes. This type of product, known as casinghead gasoline, is exceedingly volatile and is rarely if ever marketed in its original state. It is usually blended with naphtha at the plant where it is manufactured, but in the last few years a certain percentage has been shipped to the refineries and there blended with straight-run or cracked gasolines of low volatility. It is sometimes blended with kerosene, but the resulting product is not at present regarded as a very satisfactory motor fuel.

The production of natural-gas gasoline has been increasing rapidly, the production for 1917 being approximately thirty times that for 1911, and it is possible that the 1919 production was forty-five times that for 1911. This product has been of immense value in increasing the total amount of motor fuel as it has rendered available quantities of naphtha and heavy gasolines which in their original state did not contain a sufficient proportion of low-boiling constituents to make them satisfactory as motor fuels.

A relatively high percentage of the gasoline now produced is made from gas oil and other heavy petroleum

fractions by decomposition under heat and pressure. This product, known as "cracked gasoline," differs from "straight-run" gasoline in that it contains a much higher percentage of "unsaturated" hydrocarbons. "Cracked gasoline" is seldom marketed as originally manufactured, but is blended with "straight-run" or "casinghead" gasoline.

No accurate statistics are available which indicate the total yearly production of gasoline by cracking processes. A statement by President Teagle of the Standard Oil Co. to the effect that in 1919, 15 million barrels was produced by the Burton process, was recently published in *The Lamp*, the official organ of the Standard Oil Company of New Jersey. These figures indicate the importance of the cracking process as a source of motor fuel.

The Yield of Gasoline

The figures in column 3 of Table I show that in the past years there has been a decided increase in the amount of gasoline obtained from a given amount of crude. In 1904 the gasoline produced amounted to 10.3 per cent of the crude oil run to refineries, whereas in 1919 the yield was 26.1 per cent. In other words, 4.3 gal. of gasoline was produced from each barrel of crude in 1904, while 11 gal. was obtained from each barrel of crude in 1919, an increase in gasoline yield amounting to 155 per cent.

Increases in the yield of gasoline have been due partly to the improvements in refinery equipment and to relative increases in the production of light crudes, but the principal causes have been the extensive use of cracking processes and changes in the volatility of gasoline. The more general use of casinghead gasoline is also a factor of great importance.

Users of gasoline are inclined to condemn the present grades of motor fuel and discuss the "good old days" when 75-deg. gasoline was one of the less-volatile products on the market. It is not generally realized that the demand for gasoline has increased at a much more rapid rate than has the production of the raw material from which gasoline is derived. Refiners have been forced to get more gasoline out of the crude, and the most effective method of accomplishing this result is to "cut deeper into the crude" and market as gasoline certain fractions that were formerly included with kerosene.

That there have been decided changes in the volatility of gasoline during the past few years is very evident, but that such changes were necessary in order to meet the increased demand is not generally realized. Several years ago it was customary to market gasolines having gravities of 70 to 76 deg. and end points of 300 to 350 deg. F. The present average grade of motor gasoline has a gravity of 56 to 60, depending on the type of crude oil from which it is made, and an end point of 410 to 450 deg. F. It is generally admitted that this change has not been an improvement, particularly from the standpoint of convenience in operating automobile engines, but it has, nevertheless, been a decided advantage to the user as it has permitted him to obtain an abundant and well-distributed supply of motor fuel. If the higher standard of quality had been maintained, there would have been unavoidable shortages and an increase in price of an entirely different order than that which has occurred.

In a report to the Director of the Oil Division, United States Fuel Administration, on "Potential Production of Airplane Gasoline," the Bureau of Mines estimated that if all gasolines now produced were of a volatility equivalent to that of the so-called 76-deg. grade, the yield would be reduced approximately one-half, and if of the same volatility as motor gasoline marketed four or five years ago, the production would be reduced approximately one-quarter. This estimate indicates the importance that the change in volatility has had on the yield of gasoline from crude oil, for if no change had been made, instead of a gasoline production in 1919 of more than 94 million barrels there would have been a production of less than 50 million barrels of 76-deg. gasoline or less than 75 million barrels of the grade that was in general use four or five years ago.

Importance of Cracking Processes

The use of cracking processes has had a noticeable effect on the yield of gasoline. It is estimated that the Burton process has furinshed more than 10 per cent of the total gasoline produced since the process was first put into operation on a commercial scale. This added amount of gasoline has been rendered available without increasing the consumption of crude petroleum and has been of prime importance in preventing shortages of motor fuel and in conserving the supply of crude. More than 150 million barrels of crude oil would have been required to yield an amount of gasoline equivalent to that produced by the Burton process since its development.

If the demand for gasoline keeps increasing at a rate more rapid than the increase in production of crude petroleum, it is highly essential that cracking processes come into even more general use than at present. In this connection it will be interesting to observe the effect of the recent offer of the owners of the Burton process to lease the process to independent refineries. If the process is installed in refineries throughout the country, there should be a decided increase in the yield of gasoline without proportional increases in the consumption of crude, provided, of course, that there is sufficient difference between the price of gasoline and the price of fuel oil to make the operation of the process profitable.

Importance of Casinghead Gasoline

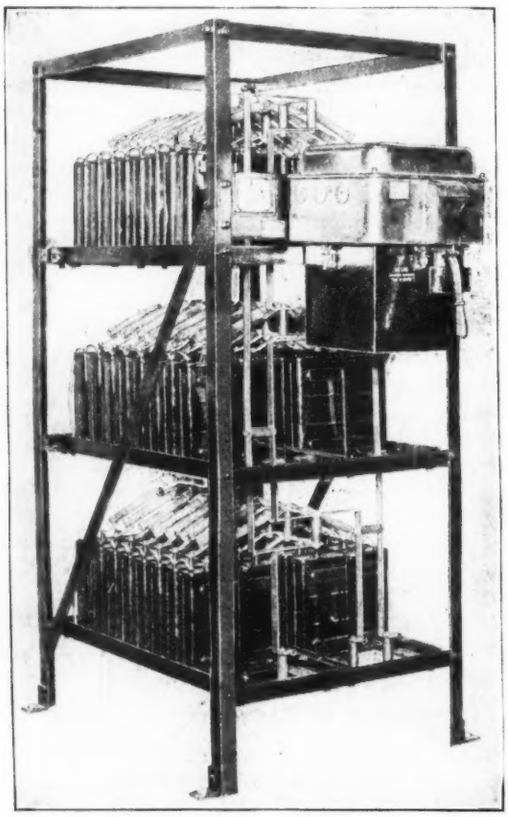
Casinghead gasoline has been of more importance in increasing the total supply of motor fuel than its production would indicate. The amount of raw casinghead produced represents only about 8 per cent of the total gasoline production, but this amount rendered available for motor fuel a quantity of naphtha or heavy gasoline at least equal to the production of raw casinghead. Without the addition of casinghead these products could not have been used to good advantage as motor fuel, as they do not contain sufficient low-boiling constituents.

A considerable percentage of the casinghead now being produced is being shipped to the refineries, where it is added to straight-run products that are deficient in low-boiling material. This method of utilization allows the refiner to "cut deeper into the crude," as he can supply the necessary percentage of low-boiling constituents by the addition of casinghead, and for that reason can increase the amount of motor fuel that can be obtained from a given amount of crude. A more even distribution of casinghead would aid in increasing the percentage yield of gasoline, for at present some gasolines on the market are deficient in low-boiling constituents, while others contain percentages apparently higher than necessary.

Static Condensers for Power-Factor Correction

The stationary, or static, condenser has been developed by the General Electric Co. to meet the demand for a means of correcting the power factor for small loads and where an attendant is not available. Condensers of this type have been standardized for installations ranging in frequency from 40 to 125 cycles, in voltage from 220 to 2,300 volts, and in capacities from 30 to 300 kva.

For the correction of power on circuits exceeding 2,300 volts, transforming apparatus consisting of a transformer or auto-transformer of sufficient capacity to step the voltage down to 2,300 volts, and a suitable



THREE-PHASE STATIC-CONDENSER EQUIPMENT FOR POWER-FACTOR CORRECTION

oil circuit breaker to control the equipment from the line side of the transforming apparatus are provided. Those for 2,300-volt service consist of a number of condenser units, a reactance for damping out harmonics in the voltage wave which would affect the corrective capacity of the units, a discharge resistance for draining the condensers when disconnected from the line, and an oil circuit breaker for the control of the equipment. For 220-, 440- and 550-volt service an auto-transformer is provided designed to step the voltage up to 1,200 volts for the condensers in order to provide more economical use for the active material. In the figure is shown a 240-kva. 60-cycle three-phase unit ready for installation.

The number of condenser units which comprise an equipment are directly proportional to the capacity required. Each unit has a capacity of 5 kva. at 60 cycles. The unit itself consists of a large number of couples of metal foil with paper laminations as a dielectric, similar to the standard construction of low-voltage condensers. These couples are treated in a vacuum to remove all moisture and immersed in oil in a container which is hermetically sealed to prevent possible absorption of moisture from the air. In practice the units are connected in parallel across each phase, one terminal being connected through a fuse which has a threefold purpose: First, to provide protection for the units from damage due to any abnormal potential; second, to open the circuit of the unit to the bus in case of failure of that unit; and third, to provide an easy way of reducing the capacity of the condenser equipment in case of seasonal changes in the load when the full corrective capacity is not required.

The principal advantages of the static condenser are small losses, ease of installation, absence of moving parts and the fact that no attendant is required for its efficient operation. When one considers the evil effects of poor power factor on operating conditions, it is easy to realize that such a device, which is a highly efficient corrective, is a most valuable asset, both from the standpoint of the central station and that of the factory owner with a load of low power factor.

Two Mammoth Waterwheels for Fall River (Cal.) Plant

The Mount Shasta Power Corporation, a subsidiary company to the Pacific Gas and Electric Co., of San Francisco, Cal., has recently placed orders with the Allis-Chalmers Manufacturing Co. for two large hydro-electric units. Each waterwheel will be rated at 40,000 hp. and is to operate under a normal effective head of 421 ft. at a speed of 275 r.p.m. The water will be led to the unit through a penstock 9 ft. in diameter and at the entrance to the turbine will be controlled by a butterfly valve 9 ft. in diameter, forming a part of the turbine. Each unit has a vertical shaft 24 in. in diameter. The spiral casing is of cast steel and will be made in five sections. Each machine is to be equipped with a telescopic draft tube, directly connected governor, and a pressure regulator with a 48-in. connection to the spiral casing. The pressure regulator is designed to discharge 80 per cent of the capacity of the turbine, which means that for the few seconds that the governor must operate, it must divert completely and largely dissipate 32,000 hp., and maintain a very carefully graduated control. An efficiency of 89 per cent has been guaranteed by the builders, this high guarantee being justified by the use of the White Hydraucone Regainer.

Each of the turbines drives a 35,000-kva. 1,835 ampere 11,000 volt three-phase 60-cycle 275 r.p.m. generator. The two units are to be installed in a new station known as Fall River Plant No. 1, Fall River being a branch of the Pit River, which drains the region north of Mount Lassen and south of Mount Shasta in California. The power is to be transmitted to the Pacific Gas and Electric Company's transmission systems in and around San Francisco by means of a transmission line about 210 miles long. It is contemplated to transmit the current at 210,000 volts.

Power is glad to be able to promise its readers some interesting information as to the details of the apparatus going to make up this unusual development as soon as the machines are completed and placed in service the early part of next year.

EDITORIALS

Economy in Industrial Power Plants

MODERN development in power plants has resulted in economy not only in fuel, but also in equipment and building space. In the boiler room the introduction of the mechanical stoker has made possible the forcing of boilers three hundred to three hundred and fifty per cent of their normal rating; thus the same load may be carried with approximately one-third the number of boilers as required where hand-fired units are used of the same normal rating, besides resulting in much better fuel economy. In the power plant the steam turbine has made it possible to reduce the space per horsepower of installed capacity many times below that required by the reciprocating-engine-driven units. Not only is this true of the main units, but it also applies to the auxiliaries. In industrial plants where large quantities of waste heat from processes are available, the utilization of this heat has resulted in large coal savings. The leading article in this issue describes the power plant of the International Nickel Company of Canada, where the foregoing is very nicely exemplified, in an industrial plant.

Fuel economy accomplished by the utilization of waste heat in this plant is of particular interest at this time, in view of the high price of fuel and the difficulty in obtaining it. By installing a four-hundred-horsepower waste-heat boiler on each of the two nickel-refining furnaces, it has been possible to operate with one less coal-fired boiler in the power plant. The utilization of the cooling water from the rabble arms of the calciner furnaces for boiler feed and the large quantities of hot water used in the processes also results in a large saving in fuel, amounting to the equivalent of approximately another six-hundred boiler-horsepower, and indicating some of the possibilities of waste-heat utilization. Fuel saving, although the most important, is not the only thing accomplished; there is also the saving in cost in the boilers by a reduction in the number installed and also in the size of the boiler room. The power-plant equipment throughout operates at speeds that make the space occupied per unit capacity very small, and this makes for economy in plant dimensions. Some of the old reciprocating blowing engines of one thousand horsepower capacity occupied a space approximately the same as required for this plant having a capacity of five thousand horsepower of high-speed turbo-blowers and turbo-direct-current generators. One-thousand-kilowatt direct-current generators operating at seventeen hundred revolutions per minute and one-thousand horsepower turbo-blowers operating at eight thousand five hundred revolutions per minute such as used in this plant, even in this period of high-speed equipment have not as yet become general practice, although they indicate what the future may hold.

Metal-refining industries, along with many others, are generally offensive to most communities on account of their smoke and obnoxious gases and also because of the pollution of streams with the water from their processes. The plant under discussion is a good example of how these objections can be overcome by giving them proper consideration in the design. Instead of the water from the processes going back into Lake Erie polluted, it is subjected to a treatment that gives an effluent free from objectionable matter, and all solid matter is removed from the gases before they reach the stacks.

Feed-Water Heating

THE design of power stations with turbo-generators of large size has introduced a number of new problems connected with feed-water heating.

High-pressure integral economizers or steel tube economizers, now used in standard practice, require feed water to be at a temperature of about two hundred and ten degrees Fahrenheit. There are several methods available to heat the feed up to this temperature and maintain a proper heat balance on the plant.

The method that has been popular in this country for many years requires the use of non-condensing steam driven auxiliaries with their exhaust steam used in an open heater. There are two objections to this system: First, it is very difficult, if not almost impossible, to maintain a heat balance under all load conditions, and secondly, the heat energy of the steam available to produce work can be only partly utilized in these small units.

Electric motors can be used efficiently for practically every auxiliary service, and their use has been greatly extended in the newer power plants. There are three possible methods of heating feed water with all electrically driven auxiliaries, the first of which is as follows: A non-condensing house turbo-generator tied electrically to the main generator busbars can be installed to furnish exhaust steam to heat all the feed water in an open heater to two hundred and twelve degrees Fahrenheit. When the main generating units are large, this involves a large house turbine, which, in heating the feed water to the required temperature, may develop much more power than is needed by the auxiliaries. This surplus power passes out onto the system over the main busbars.

A second method is to bleed the main turbine at a point near the exhaust end where the pressure will be about twenty inches of vacuum at normal load. This bled steam is used in a closed heater to heat the condensate on its way to an open heater. A non-condensing house turbine is installed just large enough to carry all the electrically driven auxiliaries and to heat the feed water through the remaining temperature range in the open heater into which it exhausts. Double auxiliary busbars are provided, one set connected to the house turbine and the other to the main generator. The heat balance and desired feed-water temperature at the open heater may be maintained at all times by shifting the load of the auxiliary motors to or from the house turbine to the main generator busbars.

The third method consists of bleeding steam at two or more points on the main turbine, so that at normal

load the steam leaving the connected closed heaters will be at the required temperature. No open heater is used in this system. In fact in both this and the previously described systems the only steam-driven auxiliaries are usually a boiler-feed pump and sometimes a forced-draft fan. The condensate pump forces the condensate through both heaters on its way to the hotwell, where any necessary makeup water is added. The disadvantage of this system is that the pressures vary at different stages as the load changes and at light loads the temperature from heaters so connected will probably be quite low. On the other hand, this latter method is most economical at rated load of all three systems if one considers the gross steam demand on the boilers in each case. In the third system the greatest amount of the available heat energy resulting from expansion of the steam is recovered as work in the highly economical main unit. This system is under consideration for several large new stations.

Several engineers favor the second system, since it is generally only slightly less economical in gross steam demand on the boilers than the third system, while it has the advantage that the heat balance can be adjusted at all loads.

Feed-water heating is an individual problem in every large station and must be studied carefully to get best results.

Social Engineering at A. S. M. E.

TO THOSE who are wont to regard the mechanical engineer as a sort of glorified mechanic the program adopted for the celebration of the fortieth anniversary of the founding of the American Society of Mechanical Engineers may seem a little beside the mark. It was, however, demonstrative of the broad view which the society has lately taken of its functions and of the inclusiveness of its field. In considering The Opportunity and Responsibility of the Engineer the program dealt with him as the administrator rather than as the designer and creator.

An address by J. Herbert Case, acting director of the Federal Reserve Bank of New York, threw up a fitting background for the engineer in this rôle. The workingmen's side was presented by Samuel Gompers, president of the American Federation of Labor. The high point of his discourse was the thought that the workman should be considered as the real product of industry, the goods or service produced as the by-product. His address was moderate and conservative.

William B. Dickson, vice-president of the Midvale Company, Inc., captain of industry and large employer of labor, expressed in his address the convictions that have been growing in the minds of an increasing number of responsible thinking people who can see out over their immediate personal interests into the real problems of our industrial life. "The feudal system," he said, "was based upon the ownership of land and its appurtenances, such as highways, mines, streams, fisheries, etc., by the barons, and it was effective in securing autocratic control of the workers because the vast majority were tillers of the soil or workers in other industries controlled through land ownership.

"The tendency of our modern industrial system is toward autocratic control of the workers through ownership of what our socialistic friends call the 'tools of production,' which include not only the natural resources, but also the furnaces, mills, factories and transportation systems."

He cited two cases where, in order that prices might be maintained in the face of a diminishing demand, great companies had decided to shut down their plants. The result was disaster to the communities where they were located. Merchants were driven out of business, real estate values were depreciated, and workers had to break up their homes and seek employment elsewhere. None of these persons had any voice in the momentous decision, made in a New York office.

"By reason of this condition we have the unstable situation of a government founded on the suffrages of men who for all practical purposes are industrial bondmen.

"The Carnegie labor policy was highly autocratic as is that of its successor, the United States Steel Corporation, a benevolent autocracy, if you please, in many splendid ways, but however large you write the word benevolent you must always write after it the word autocracy.

"Any manifestation of autocracy is repugnant to the American people whether it proceeds from a president of a corporation, a president of a labor union, or a president of the United States.

"The answer is industrial democracy."

And the looks of intelligent approval with which the address was followed indicated no less than the hearty applause which came upon its conclusion that the big intellectual audience that filled the auditorium found such broad views and fearless utterances good to listen to.

How About Boilers?

ON PAGE 786 of this issue there is printed a short analysis of data on boiler explosions covering the period from 1880 through 1919. This material is presented more with the idea of showing what may be done than for the purpose of giving precise information.

The figures upon which this analysis is based are not precise—they could not be under the circumstances. For forty years the Hartford Steam Boiler Inspection and Insurance Company has painstakingly been compiling them, and now vouches for their accuracy as far as they go. But this company was one among many and had neither the authority nor the facilities for searching out all the facts in connection with every explosion, much less for keeping track of every boiler installed.

The company that made this survey did so on its own initiative, at its own expense and for its own purposes. The results are helpful and welcome. Yet nobody has so far been given the responsibility and the means of securing precise and all-inclusive data; "let George do it" has been the rule of procedure.

Every ten years Uncle Sam counts noses to see how his family has grown. A great many other things are counted, too; in fact, the Government keeps records of pretty nearly everything except, perhaps, boilers. It may be that boilers are not important enough, as their toll of dead and injured is reported to be only 695 per year. Perhaps, too, the registration of boilers would make too much red tape and would cost too much.

Meanwhile the state insists that every dog shall have a license, and a careful record of licenses is kept. Motorcycles are registered; so are automobiles.

But boilers are different.

CORRESPONDENCE

Pit Holes in Feed Pipes

In *Power* of Sept. 28, 1920, page 514, C. W. Wallace writes that he is having trouble with pit holes in his feed piping. This is fairly common with steel feed pipes and occurs with most waters, the quality of steel having little apparent effect on the corrosion. There appears to be no doubt that the trouble is caused by the combined chemical and electrolytic action due to dissolved oxygen in the water, and the obvious remedy is to get rid of the oxygen before the water is pumped through the pipes.

An apparatus to accompish this is described by F. W. Speller and R. C. Knowland in the *Journal* of the American Society of Heating and Ventilating Engineers, pages 249-59, January, 1918, also on page 426 of the Sept. 14, 1920, issue of *Power*.

The corrosion of feed pipes is very ably dealt with in *Power*, Feb. 26, 1918. In this article the activity is said to be at a maximum when the temperature of the water is approximately 14 deg. F., decreasing as the temperature of the water rises.

The following case shows how far this agrees with practice. A certain boiler plant consisting of six Lancashire boilers 8 ft. 6 in. in diameter and 30 ft. long, working at 120 lb. pressure, was arranged with 4-in. steel feed piping, lapwelded, with flanges screwed and expanded on. Each pair of boilers was served with an economizer having 192 tubes. The feed pump was of the vertical direct-acting type, drawing water from an open feed tank. The average temperature of the water entering the economizer was from 130 to 140 deg. F., the average temperature of the water leaving the economizer from 260 to 270 deg. F.

After the piping had been in use about twelve months several pit holes were observed in the pipes leading to the economizer, necessitating putting on clamps until the pipes could be replaced.

An examination was then made. Six pipes leading to the economizer were found to be in a very badly pitted condition internally, and five leading from the economizer were practically as good as new. The trouble was remedied by fitting cast-iron pipes leading to the economizer.

It is nearly three years since the steel feed pipes were first put in, and those leading from the economizer are just beginning to show signs of pitting, which will necessitate replacing them with cast-iron ones in the near future.

The cast-iron pipes are made of hard, close-grained metal, are ¾ in. thick and were tested to 350 lb. before being used. The water supplied to the boilers was from the town supply and was not treated in any way; the analysis showed five to six degrees of hardness.

Personally, I have found that cast-iron feed pipes are satisfactory up to 160 lb. pressure provided they are of even thickness all the way round and that a spring-loaded relief valve is placed on the discharge side of the feed pump to take care of any sudden pressure due to shock. With turbo-feed pumps shock is practically absent, and in my opinion they are preferable in every way to piston pumps. W. M. HEBBLETHWAITER.

Haddersfield, England.

Fuel Waste Causes Failure of Central Heating Station

Referring to the article by William M. McNeill on page 476 of the issue of Sept. 21, I think that he worked with the wrong idea. He certainly could have turbined the 600-hp. boiler, cleaned the tubes of soot, put the baffles in shape, repatched the brickwork where required, and stopped the leaks in the boiler setting, all at a small expense. As to the chain-grate stoker, there was no reason why the bent shaft could not have been straightened, and owing to the success that we are having now with oxyacetylene, thermit and electric welding it would not be wise to throw good castings away when they could easily be repaired.

It would have been possible to run the plant with the 600-hp. boiler in first-class order, and using the hand lance twice a day results could have been shown right away, and the chances are the repairs for the three other boilers would have come much easier.

In every plant there is a certain amount of fuel loss that is out of the control of the operator; this depends largely on the efficiency of the stoker machinery used. It should be the practice to operate the boiler plant at the highest efficiency possible. Then if something new is brought out that will save enough above the old method to make its installation profitable it is time to go before the executive officers and argue the case.

There are plenty of good operating engineers, but few real chief engineers, and after the way the man who pays the bills has been stung it is a wonder that improvements are not harder to get than they are.

There is one mistake that the majority of companies make—they do not take their chief engineers into their confidence enough, whereas they should consider them as acting officers and should keep in touch with them, for they are the connection between the executive officers and the men. To get the best results they must all work together. C. D. DISPENNETTE.

Columbus, Ohio.

Excess Furnace Air Supply

Several communications have been published recently regarding excess air leaking into boiler furnaces through the cracks in the brick setting. Even though the setting may be in the best of shape, most furnaces are operated with too large an amount of excess air. Proper furnace operation, such as to obtain the best combustion of the fuel, should be had with not more than 40 per cent excess air. Air above the amount required for proper combustion, dilutes the gases and carries heat up the chimney; and not taking into account the heat that is lost in the chimney gases, the admission of excess air also causes furnace losses due to incomplete combustion because of the low temperature created in the furnace.

Most engineers, if asked to give an opinion, would say that a cracked boiler setting is a sure sign of excess air. This does not necessarily follow because it can be considered only when compared with the air entering the furnace from the ash pit or through the furnace doors while firing. If the pressure in the furnace is greater than that on the outside, air will pass out of instead of into the furnace.

Air readily passes through a clean fire, and therefore a large amount of fuel can be burned and what air leaks in through the setting will, under such conditions, be but a small part of the total admitted to the furnace. If the fire becomes dirty and filled with clinkers, a less volume of air will pass through the fuel bed and the air leaking into the furnace through the setting will be a much larger part of the total used.

Air leaking through the brick fittings is of much less importance than that leaking into the furnace through holes in the fire. Therefore, firemen should be careful not to carry too thin a fire and also to keep the fire

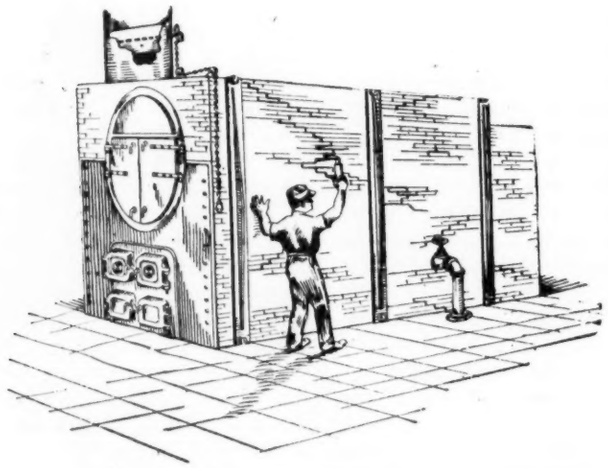


FIG. 1. DETECTING AIR LEAKS IN BRICK SETTING WITH A LIGHTED TORCH

evenly distributed on the grate. There is a large amount of combustible gases rising from the fuel, and it is therefore, essential that the proper amount of air be supplied above the fuel bed.

What has been said does not mean that air should be allowed to leak through the setting. All air leakage should be stopped and all air admitted to a furnace should be under control of a fireman. Every crack is admitting air to cool the heating surface of the boiler. It has been estimated that the loss due to air leaking into a furnace is 10 per cent of the heat generated in the furnace in the average heating plant.

There are various ways of determining where the brick setting is leaking air. One is by holding a lighted candle at the cracked places, Fig. 1, around the boiler drums, clean-out doors and where the blowoff-pipe comes out through the setting. If the damper is in the "wide open" position the flame of the candle or torch will be

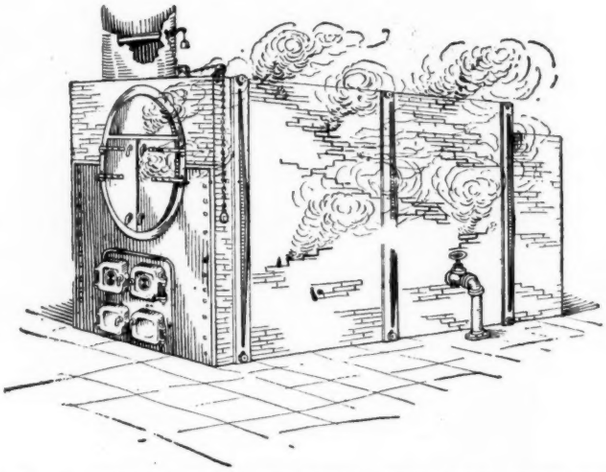


FIG. 2. SMOKE FROM FRESHLY FINE FIRE DISCLOSES AIR LEAKS

drawn into the crack. Another method is to fire up with fresh fuel with the damper wide open and then close it tight, when smoke will issue from the cracks and crevices. Marking such spaces with chalk will enable one to make repairs to the setting whenever the opportunity arrives.

When repairing cracked fittings, do not smear mortar into the cracks, but first remove the old mortar in the joints of the brickwork to the depth of at least one inch and clean off the face of the brick with an old bastard file. Then point up the brick with cement mortar and fireclay to which enough ammonia has been added to give off a strong odor. The ammonia retards the setting of the mortar and makes it more able to resist the changing temperature of the brickwork. If possible allow the mortar to stand for three days before firing up the boiler. A coat of asphalt paint makes a very good finish for the brickwork.

C. E. ANDERS.

Cleveland, Ohio.

Air Kept Centrifugal Pump Cool

We are operating a five-inch two-stage centrifugal pump several hours per day with no load, on account of its being belted to an engine that drives other machinery.

When the unit was first started, we closed the suction and the discharge lines, and opened a 2-in. pipe connection to the atmosphere. The small amount of water that was discharged into the pump casing from the thrust bearing and from the two lanterns in the stuffing boxes would not keep the pump casing cool enough. It was found out by one of our engineers that by opening all six of the air cocks on top of the pump enough air would be drawn in to keep the pump cool.

Canton, Miss. JOHN T. SHARP, JR.

Ventilation of Coal in Storage

Possibly if I knew more about the subject I would not be writing this letter, but the article "Ventilation of Coal in Storage," page 618 of Oct. 19 issue, is very interesting and the idea occurred to me that coal might be ventilated by means of compressed air. Not having data on hand as to the importance of this subject, of the capacity of storage wherein the problem presents itself, and other information on which to base figures, I cannot say whether compressed air would be commercially feasible.

As the service of compressed air to ventilate coal would undoubtedly be required at infrequent intervals, simply at such times as heat in stored coal becomes excessive, the idea may be practical. CURTISS MAIN.

New York City.

Why Does a Leaky Compressor Valve Get Hot?

I am operating, along with other machinery, a motor-driven air-compressor that runs against a 300 lb. per sq.in. discharge pressure.

This compressor is a two-stage machine and we often have trouble from leaky valves. Whenever the gage on the discharge line drops I know a valve is leaking, but I can never tell which one. Since it means removing a dozen valves to find the bad one, it was a help when the chief told me that a leaky valve always gets hotter than usual and that I could always depend on this to locate the leak. As it is usually one of the high-pressure discharge valves that leaks, I would like to know just why it gets hot. Will some *Power* reader explain to me the reason? DONALD MCFEE.

New York City.

Diesel Indicator Cards

I am operating a 500-hp. Diesel oil engine which runs at 164 revolutions per minute and am sending two

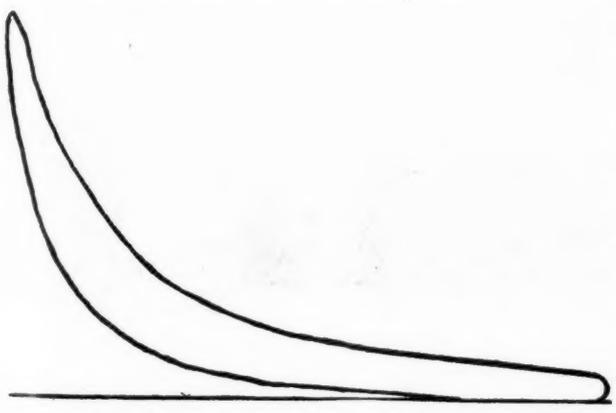


FIG. 1. FROM NO. 1 CYLINDER, 89 LB. M.E.P.

indicator diagrams for criticism by *Power* readers. These diagrams are from No. 1 and No. 4 cylinders and were taken while the engine was carrying 480 brake horsepower.

I have seen a number of diagrams published in *Power* and in various books. All that were classed as good had a fairly flat combustion line. In the cards which I send there does not appear to be any combustion line at constant pressure. In fact, they look to me as though the combustion was an explosion, as in the Otto-cycle engine.

I would like to have someone who is familiar with Diesel engines explain this to me and give some information as to how to avoid the sharpness of the diagram and to give a flatness to the combustion line.

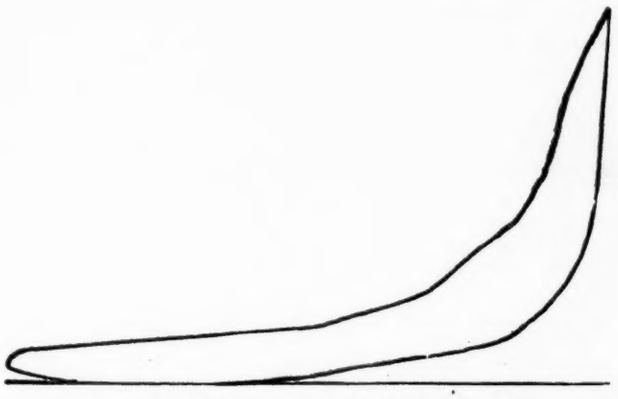


FIG. 2. FROM NO. 4 CYLINDER, 90 LB. M.E.P.

Kansas City, Mo. G. POWELL.

Pounding in Two-Cycle Gas Engine

The several letters appearing in *Power* concerning pounding in a semi-Diesel oil engine recall to mind similar difficulties I once had with a two-cycle gas engine.

This gas engine had a throttling governor on the gas supply; the engine used a qualitative mixture. On low loads the mixture was weak since the governor throttled the gas supply. On full load the governor increased the richness of the mixture and after running a few minutes the engine would begin to pound; as the load increased the thumping grew stronger, and if overloaded, the noise was such that to the uninitiated it seemed the engine would break to pieces. In fact, I shut it down more than once, thinking something was broken inside the crankcase.

The only thing that would stop the pounding was the partial closing of the gas throttle on full load. In this way the engine drew in a leaner mixture and the pounding ceased. Often, as the engine began to die down, I closed the throttle a slight amount and the machine immediately came up to speed.

It is apparent that on heavy loads the mixture was so rich that it exploded early in the stroke when the compression rose above the self-ignition temperature. The pounding, of course, came from the preignitions.

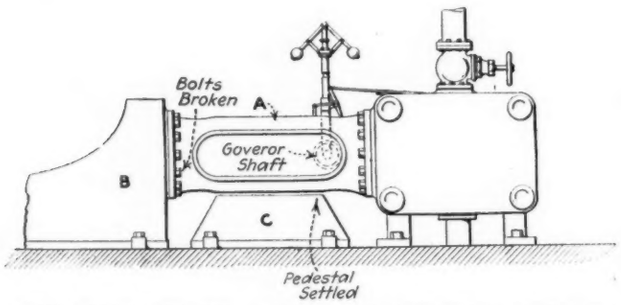
I also found that if the ignition timing was late with a weak mixture, the engine would not carry so much load and pounded badly. This was due to the crank passing dead center before the gas ignited; any looseness in the bearing was made evident by the pound.

A "sticky" or seized piston will also cause a pound. In such cases the piston has a close fit and, as it expands from the heat, grips the cylinder walls. The remedy is to turn off a few thousandths of an inch, beginning at the second ring from the top and making the cut a taper. EARL PAGETT.

Cherryvale, Kan.

Peculiar Thump on a Corliss Engine

I was called upon recently to overhaul a 600-hp. double-eccentric non-condensing Corliss engine that had given considerable trouble. On dismantling the engine, I discovered that the connecting rod had been rubbing against the crank disc while passing the back center, and by the appearance of the rod it must have been run for some time in that position, as there was an impression on the side toward the disc six inches long and from nothing to one-fourth-inch deep. This was caused by the crankshaft being out of alignment. The peculiar part of this incident is that the operating force claims that the bearings never overheated under these conditions.



STUD BOLTS BROKEN, CAUSED BY PEDESTAL SETTLING

It was necessary to turn the crankpin and put in new brasses and new shoes, brasses and a pin in the crosshead and line up the engine. When the engine was again put in operation, it ran very smoothly and gave no trouble for about three months; then it started to develop a thump that sounded very much as though the piston was striking the back head, but on stopping the engine and locating the striking points we found them to be all right. When it was started again, there was no knock or thump for two days; then it started to thump at intervals of about three or four minutes for about an hour, when it stopped. This continued off and on for three months, and during this time I visited the plant every Sunday to work on the engine when it was down, and once or twice a week when it was under load. I indicated the engine several times under different loads and steam pressures, but this did not bring me any nearer to solving the difficulty.

Then I decided to call in two engineers in consultation to see if we could locate the difficulty, but after spending eight hours going through all the procedures we could think of that would overcome the trouble, we were no nearer a solution than when we started.

While putting the indicator on, I heard a faint squeaking noise as though something needed oil; I asked the oiler what that was, and he said it was the governor pulley rubbing the safety guard. On looking at it, I saw that the pulley was striking on one side, and by watching it I noticed that it would strike when the engine was on the back stroke, and as the governor shaft is fastened to the crosshead piece *A*, it showed that the connecting piece was moving first one way and then the other at right angles to the stroke of the engine.

On closer inspection I discovered that of the twenty bolts holding the distance piece to the frame *B* of the engine all were broken but three, two on the bottom and one on the top, caused by the pedestal *C* settling about a quarter of an inch, which allowed the distance piece to spring, causing the crosshead to twist on the back stroke and throwing the crank end of the rod against the disc when the load was at a certain point. After the bolts had been renewed and the pedestal raised to place the thumping ceased. C. J. MILLER.

North Tonawanda, N. Y.

Prevented Steam in Compressor Water Jacket

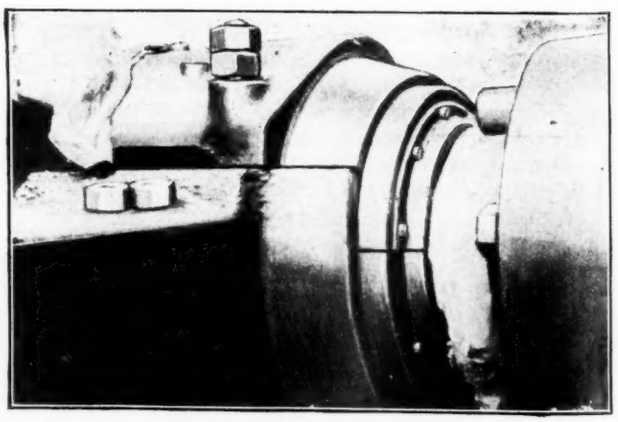
A well-known type of cross-compound air compressor was sent out from the factory with a ¼-in. pet-cock screwed into the highest part of the water jacket on the low-pressure cylinder for releasing the steam that might accumulate at this point. It was found that in practice this cock was seldom opened, and to obviate this non-automatic feature, it was removed and enough ¼-in. pipe and fittings used to run this discharge to the funnel that catches the cooling water coming from the cylinder. A small part of the cooling water is discharged from this pipe and thus prevents any accumulation of steam.

Canton, Miss. JOHN T. SHARP.

Repair to a Diesel Main Bearing

Fractured Diesel crankshafts are not of everyday occurrence. When one does let go, usually some other engine part suffers.

In a recent crankshaft failure the section next to the flywheel was thrown to one side, breaking the end main bearing. The upper half of the bearing housing was broken away, taking with it a part of the lower housing. The upper half, with an entire new shell, was secured from the manufacturer. To repair the fracture in the lower part, electric welding was resorted to. The surface



WELDED DIESEL BEARING

was thoroughly cleaned and a row of steel studs inserted into tapped holes along the break. The welding material was then built up around these studs. From an examination of the repair it seems that the added material has not actually united with the cast iron of the base. The steel studs apparently were welded into the added material and serve to bond the two parts together. The bearing is perfectly satisfactory in service, and the weld shows no signs of giving way. E. E. SNOW.

New York City.

INQUIRIES OF GENERAL INTEREST

Advantage of Multi-Valves for Pumps—Why are many small valves used in a pump instead of a few large ones? C. T. C.

Small valves have less lift and therefore can open and close quicker and are subjected to less wear from pounding on their seats; there is less friction, and the shorter studs or spindles are less likely to become broken from shocks or unequal distribution of pressure; they are cheaper to construct and repair, and the valve seats are easier to replace than those of larger valves.

Burning Mixed Sizes of Coal—For hand-firing boilers, is it better to stoke mixed sizes of coal or fire with one size at a time? R. N. G.

The best results are obtained when there is greatest uniformity in size of the coal. When large and small sizes are mixed together in equal proportions there is more obstruction to the draft than from use of only a smaller size, as the fire becomes dirty before the larger sizes have been consumed and in cleaning the fire there is greater waste of unburned coal. Greater economy is to be obtained by suitably firing the different sizes separately, and if that is not practicable for obtaining the necessary boiler capacity the different sizes should be stoked in alternate layers with changes of size and thickness of the layers so timed as to obtain complete combustion.

Advantages of Early Release—What is the advantage of releasing steam before the end of the expansion stroke? W. B. G.

Since some area of the indicator diagram must be lost in expelling the exhaust it is better that the loss should be above than below the expansion line, for in bringing the piston to rest at the end of the stroke there is no object in keeping up the forward pressure near the end of the stroke at the expense of requiring higher compression on the opposite side of the piston. When a condenser is used release before the end of the stroke insures prompter realization of the vacuum for the return stroke with a larger percentage of the load thrown on the condenser, as the larger area in the vacuum portion of the diagram calls for earlier cutoff and less initial steam.

Hunting of Shaft-Governed Engine—What makes a shaft-governed engine hunt? A. H.

The force of governor springs and effective centrifugal force of the weights are unbalanced and alternate in overcoming each other. The remedy is to give less tension on the springs to decrease sensitiveness, and changing the weight to get the desired speed. Hunting and racing may be caused also by friction of the governor parts or connections. When caused by friction the weights will remain on their inner position until the speed developed is so high as to throw them out with a noise; or when the engine is above speed they will stick where they are until the speed is reduced enough for the springs to draw the weights back again.

Safe Temperature for Storage of Ammonia Drums—What is the safe temperature for storage of ammonia in drums? A. H.

Liquid-ammonia drums are supposed to be made strong enough for handling the ammonia without danger of rupture of the drums from pressure of ammonia that would be due to ordinary atmospheric temperatures. The safe temperature for storage of ammonia in drums, therefore, should be considered as not higher than about 80 deg. F. But to insure against absorption of heat to a high temperature, ammonia drums should not be exposed to the direct rays of the sun; that is, they should be kept in the shade and the drums should not be stored in a place like an engine or boiler room, where they may become heated to a higher temperature than about 80 deg. F.

Horsepower Required to Raise Water—What number of horsepower would be required to raise 2,500 gal. of water to a height of 60 ft.? W. S. R.

Horsepower is a rate of doing work, and the number of horsepower required to be developed while raising 2,500 gal. of water to an elevation of 60 ft. at a uniform rate would depend on the time employed. A gallon of water weighs 8.33 lb., and 2,500 gal. would weigh $2{,}500 \times 8.33 = 20{,}833$ lb. If the pumpage of 2,500 gal. is performed in one hour, then there would be $20{,}833 \div 60 = 347.2$ lb. of water pumped per minute; and if elevated 60 ft. the net work would be $347.2 \times 60 = 20{,}833$ ft.-lb. per minute. As one horsepower is development of work at the rate of 33,000 ft.-lb. per minute the net power developed would be at the rate of $20{,}833 \div 33{,}000 = 0.6$ hp. Neglecting pipe friction, the power required to be developed on the steam end of a pump to develop an actual or net horsepower, would depend on the mechanical efficiency of the pump. For pumps of the size required the mechanical efficiency would be about 60 per cent, and the power required to be developed on the steam end for development of 0.6 hp. in the water end would be about $0.6 \div 0.6 = 1$ i.hp.

Drier Steam With Reduction of Pressure From Wiredrawing—How does steam become drier or superheated by the process of wiredrawing? E. M.

When steam flows through an aperture the discharge takes place in consequence of the difference in pressure on opposite sides of the aperture, and in its passage through a reducing valve or other form of opening, without doing any external work, there is practically neither loss nor gain of heat per pound of the steam. There is relatively small loss due to work required for overcoming inertia, and the heat that is converted into work required for overcoming friction is restored to the steam or, under favorable conditions, a portion of it may be lost by radiation. Hence, ordinarily, after thus expanding to a reduced pressure, each pound of the steam contains more heat than necessary for the same percentage of dryness that it had at the initial pressure; so that the process of wiredrawing, whether performed by passing the steam through a throttled valve, a pressure-reducing valve or other form of aperture, converts wet steam into a drier steam at the lower pressure, dry steam to steam that is superheated for the lower pressure, or may convert superheated steam to steam at a lower pressure with more degrees of superheating for the lower pressure than it had for the initial pressure.

Notable Meeting Marks 40th Anniversary A.S.M.E.

Four Founder Societies Join in Celebration—"Opportunity and Responsibility of the Engineer" Discussed—Prominent Representatives of Capital, Labor and Management Heard—William B. Dickson Startles His Hearers

"AGE is an enfeebling influence in the lives of men, but to associations of men it may give ever-increasing vitality, strength and influence." With this aptly chosen thought, President Fred J. Miller opened the Anniversary Meeting of the American Society of Mechanical Engineers on the evening of Nov. 5. After a few introductory remarks, he presented the first "speaker," the Magnavox. This is an electrical sound-reproducing instrument which has been developed by Prof. Bristol, a member of the society. A double-faced record was used; the first side gave a message of greeting from Ira N. Hollis, past president of the A. S. M. E., and when the second side was used, President Miller had the unique experience of listening to himself making a speech.

The subject of the evening had been announced as "The Opportunity and Responsibility of the Engineer," but before introducing the principal speakers, President Miller called upon the representatives of the four founder societies for brief addresses.

Founder Societies Participate

The first of these speakers was Henry R. Towne, the oldest living past president of the A. S. M. E. Mr. Towne gave some reminiscences of the early days of the society. He recalled that he became a member in 1882 and attended his first meeting in October of 1883. The attendance at that meeting was 150, and the number of members was about 600. For the year 1883, continued Mr. Towne, the society's income was $7,560; of this $7.56 was a balance carried over from the previous year. These figures provide an interesting comparison with the $500,000 budget proposed for the coming year. Mr. Towne discussed a paper which he had presented at a Chicago meeting of the society in 1886, entitled, "The Engineer as an Economist." At that time he proposed that engineers take up the responsibility of the study of economic and allied subjects. The idea has since taken root, and indeed, the interest of engineers in the subject of economics was amply demonstrated by the program which was to be presented that very evening. As a result of this responsibility, which engineers have accepted, it becomes their duty not only to secure efficiency of methods and machines, but also to work for co-operation among those who direct the processes of industry and those who perform the work.

A. P. Davis, president of the American Society of Civil Engineers, presented the greetings of his organization, which is the oldest engineering society in the United States, and congratulated the A. S. M. E. on its rapid growth and ever-widening activities. He expressed strongly the hope that the American Society of Civil Engineers and other associations would join the Federated American Engineering Societies, and in this way expand the usefulness of engineers all over the country. "The minds of mankind," he said, "are in a state of flux." It is the duty of engineers to crystallize the thought and guide the energy of men in the right direction.

W. L. Saunders was introduced as the past president of the American Institute of Mining and Metallurgical Engineers, and also as the representative of Herbert Hoover, president of that society. Mr. Saunders pointed out that the object of the meeting was to bring home the achievements of the past forty years, but suggested that the members should devote their attention also to retaining the advantages that have been won and carrying them to greater usefulness. He gave it as his opinion that the profession of mechanical engineering is a basic one and is even of more importance than any other branch of engineering. The big men of the civil, electrical and mining branches, he said, must have a thorough knowledge of mechanical engineering as a foundation, because in all their work they must depend upon machinery of one kind or another. He felt that the spirit of collectivism versus individualism is admirably represented by the four Founder Societies.

Mr. Scott, past president of the American Institute of Electrical Engineers, illustrated his speech with lantern slides, showing a comparison between the increase in population in the United States during the past forty years and the increase in the use of various products of the engineer's resourcefulness. These slides demonstrated the speaker's point that engineering progress has been extremely rapid, until now, with the creation of the great forces liberated by engineering genius, has come a very great responsibility of the engineer in the way of controlling these forces and keeping them in operation. As to the opportunities of the engineer, he pictured the field as most inviting. Our methods, though we have continually improved them, are still wasteful and inefficient, and in this lies the engineer's great opportunity. The solution of labor troubles is another opportunity before the profession today, and when Mr. Scott said, "The modern engineer is a director of human activities as well as of inanimate operations," Mr. Gompers voiced his approval by starting the applause.

Mr. Miller then drew a laugh from his audience by saying that engineers sometimes have some business to do with banks and that, therefore, they should be interested in hearing an address from the next speaker, whom he introduced as J. Herbert Case, acting governor of the Federal Reserve Bank of New York.

The Banker a Financial Engineer

Mr. Case congratulated the society upon its forty years of progress and upon the fact that its list of members represents a roster of men who are leaders in thought and action. He pointed out that three directors of the Federal Reserve Bank of New York were drawn from the membership of the American Society of Mechanical Engineers. Mr. Case's address was a thoughtful one, carefully prepared and notable for its frequent use of analogies. In fact, his entire speech was based on the parallel which he drew between the engineer and the banker. In this connection he called the attention of his hearers to the fact that the constitution of the Federated American Engineering Societies defines engineering as "the science of controlling the forces and of utilizing the materials of nature for the benefit of man." He then went on to develop his idea that bankers have essentially the same problems before them as engineers; he referred to bankers as financial engineers and said that they are now coming to use essentially engineering methods. He felt strongly that the recent period of inflation, which we are apparently passing in safety, might have developed into a very serious crisis had it not been for the preparations made by bankers to meet just such a contingency. These preparations consisted principally in the establishment of the Federal Reserve system, by which one-third of the number of banks in the country, representing two-thirds of our banking resources, have practically pooled their resources to the end that individual failures may be averted. This action Mr. Case compared to the allowance made by engineers for a "factor of safety"; the idea being, in both cases, to provide beforehand whatever strength will be needed to cope with any emergency that may arise. The speaker suggested that it is not unreasonable to suppose, that as a result of improved financial methods, we have probably seen our last general panic. "But," he continued, "I look farther ahead than that." As engineers are never satisfied with the machines they have created, but continually work and strive to improve upon

them, so bankers will finally improve their methods to such a point that they can avoid not only catastrophies such as panics, but even the minor crises and financial disturbances which trouble us so greatly today. It ought to be possible in this way to restrain American enthusiasm from going beyond the safety point and to apply the brakes efficiently, yet gradually; it should be possible to develop a smoothly working governor that would free us from our present troubles with fluctuations in prices. Mr. Case emphasized the point that if we can do this, we shall have gone a long way in the elimination of social and labor disturbances; and in conclusion said:

"You have given American engineers and American engineering the highest place in the world. Some of your achievements, the feats that you have accomplished, are among the marvels of mankind. You have set a wonderful and, I may say, a difficult example to follow. What I wish you to know is that much the same ideas, much the same aims and methods, are at work now in the development of the Federal Reserve System of the United States."

The Labor Point of View

Samuel Gompers, president of the American Federation of Labor, was the next speaker. The keynote of his address was to the effect that "One of the difficulties that arise nowadays about our discussion of responsibility is that we fail to realize that professional men, whether doctors, lawyers or engineers, should be in a very real sense agents of society and not merely masters in their particular professions." He thought it unnecessary to review the achievements of engineers in mechanical ways, but declared that a very serious error is frequently made in describing manufactured articles as the product of an industry. It is not the inanimate objects produced in the factory that count; it is the men developed there. In other words, "men, not things, are the true goal of civilization." In a realization of this fact lies the engineer's opportunity to develop co-operation between capital and labor. There is a great future ahead for both capital and labor if they will join hands with engineers and make an effort to improve the conditions of labor, to give the workman a chance for self-expression in his daily work and to relieve the deadly monotony of repetition work, which is the principal cause of labor troubles. In our mad rush for efficiency we have allowed the man to become too greatly a part of the machine. The old spirit of craftsmanship has gone, so that men's work today tends to become mere toil. Mr. Gompers drove home his point with this vivid warning: "Beware that the machines you create do not become a Frankenstein and enslave the human race." The avoidance of this danger is a part of the coming responsibility of the engineer. In conclusion Mr. Gompers said: "If you will study the laws of humanity with the same degree of intensity that you study the laws of material science, you will render a tremendous service, and as president of the American Federation of Labor it is my firm conviction that the labor movement not only welcomes, but invites, your co-operation."

Radical Stand Taken by Mr. Dickson

The next speaker was William B. Dickson, the vice president of the Midvale Steel and Ordnance Co. Mr. Dickson's address was remarkable for the fact that he so frankly and so whole-heartedly espoused the cause of the workingman. In fact, he was hardly less emphatic than Mr. Gompers himself. For this reason his speech may be said to have been the feature of the evening. Mr. Dickson expressed the same thought which had just previously been spoken by Mr. Gompers; namely, that our modern system of the division of labor, consisting in the assignment of a highly specialized task to each individual workman, has deprived men of the joy which they once secured through the exercise of creative instinct in their work. The result of this condition, he said, will tend to stunt men mentally, morally and physically, unless it is counteracted by some other vital force. It cannot be met by reverting to original and obsolete methods; our factories must continue to produce efficiently, but not at such a sacrifice of individuality. "This is a human problem," said Mr. Dickson, "and I have not been able to solve it, so I am leaving it to you." He then read a poem on efficiency by Walter Prichard Eaton. "It has been said," he continued, "that free government is more important than good government. I believe that this is substantially true; and I would say that if there must be a choice, it is better to be free and inefficient than to secure efficiency by having men become mere cogs in a complex social machine, operated by a so-called superior class. I am afraid that we are making a fetish of efficiency." There is, however, another broader and more important question than this; it is the great issue between democracy and autocracy. We have been accustomed to consider that this question was solved in 1776, as indeed it was, politically; but in industry the present tendency is to revert to the feudal system of despotism. This has been exemplified in the past few months by restriction of production, and even the closing down of plants, with the object of holding prices up. An example that is still fresh in our memory is that of the large textile mills which were shut down completely, resulting in great suffering to the entire community. It is this "unconscious insolence of conscious power" which is at the root of our industrial difficulties. "Consider, for a moment," said Mr. Dickson, "the despotic power which our modern system of industry gives a few men over the lives and fortunes of hundreds of thousands of their fellow citizens. By reason of this condition we have the unstable situation of a government founded on the suffrages of men who, for all practical purposes, are industrially bondsmen." We are approaching the time when we shall need an industrial Lincoln, to say: "A house divided against itself cannot stand; this nation cannot continue to exist politically democratic but economically autocratic." The appreciation of the audience at this point resulted in a round of applause, which was again led by the president of the American Federation of Labor. In fact, Mr. Gompers, after the first few moments of Mr. Dickson's address, seemed to be enjoying himself thoroughly.

Constructive Recommendations

Mr. Dickson declared himself to be in favor of a fair system of collective bargaining and of giving workmen some share in the conduct of business, probably through applying a portion of their wages to the purchase of stock in the company. These systems, of course, must be designed to meet the needs of the particular plants which are to use them; and unless they are permeated with democratic principles there can be no solution of our labor troubles. To paraphrase St. Paul, "Though they pay the highest wages, give pensions, and furnish every modern convenience and safeguard to their workmen, and have not democracy, it profiteth them nothing." Some people may claim, however, that they are satisfied with present conditions and do not desire a change. This is only an evasion of the issue. The choice does not lie between industrial democracy and the present way of doing things; it lies between industrial democracy and a condition of chaos and feudalism such as we see in Russia today.

The speaker offered two suggestions to meet the situation. First, he said that we should democratize industry, giving recognition to management and labor as equal partners with capital; and second, we should teach democracy in the schools as thoroughly as we now teach reading, writing and arithmetic, so that the coming generation will be thoroughly grounded in democratic principles.

"I am not looking forward," concluded Mr. Dickson, "to the new era of industrial democracy as a period of peace and serenity, but rather as a time in which the way has been cleared for a further toilsome climb up the spiral of evolution."

Between the speeches President Miller read a number of congratulatory telegrams, notably those from Herbert Hoover, E. S. Carman, the president-elect of the society, Governor Coolidge and Senator Harding.

The best thing about this meeting was that it had what the college boy calls "pep." The speeches were not idly flattering outpourings of verbiage; they represented the carefully thought out and deliberately expressed opinions of some very able men. The American Society of Mechanical Engineers deserves great credit for having arranged and conducted such a successful meeting.

Revision of Standard Petroleum Specifications

The revision of the standard specifications for petroleum products which guides all Government petroleum purchases is under consideration by the committee which represents the various Government departments, as designated by the President to participate in this work in the original order of July, 1918. The public conference on this matter which was held Oct. 18 in Washington was attended by representatives of all the Government departments interested, state oil inspectors, oil producing and refining interests, and automotive interests.

The specifications particularly under consideration were those for gasoline, kerosene, burning oils, fuel oils and a wide variety of lubricants. In executive session the committee continued consideration of the proposals for the two days following the public conference, and it is expected that the revision of the standards will be completed within a short time and revised standards published covering all these materials. In this connection it should be understood that the committee will continue only until six months after the proclamation of peace, as it is one of the war-time agencies still functioning. Nominally, the specifications which it adopts relate only to Government purchases of petroleum, but in practice a number of states are adopting the specifications, particularly those for gasoline, and a number of large purchasers outside the Government also use them. They are, therefore, of much wider significance and interest than otherwise.

State Adoptions of Federal Standards

Four states have already adopted the motor gasoline specifications of this Federal committee, and others give evidence that they are likely to do so. Some states are writing the specifications into the state law; others simply provide that the latest specification of the committee shall govern, or place the matter in the hands of a commissioner. The question of states rights as compared with Federal supervision of course enters as a factor. The question also is raised as to what will be the significance of these state laws when the present committee no longer exists.

The advantage of state regulation in contrast with Federal legislation seems to be wholly with the smaller refiners, who like to have different standards which will permit disposal of their poorer products in states where less rigid requirements prevail. It was the consensus of opinion that in every state whose laws do specify gasoline standards, the refiners, and particularly the larger operators, are very careful as to the quality of material shipped into that state. It seemed to be generally agreed that a uniform law for the entire country would not in any way reduce the total gasoline production. It would interfere, however, with careless operations in interstate traffic, especially by tank-wagon practice near certain state border lines, and would also necessitate improvement of plant practice by some of the smaller operators. The large advantage in uniform standards for all of the country would be economy in storage and handling, for only a single set of gasoline-handling equipment would be essential under such circumstances, except of course for special gasolines such as aviation fuel, dry-cleaning gasolines, etc.

The question was raised whether the companies would all actually comply with a general standard were it adopted. Almost unanimous opinion prevailed that there would be no difficulty in securing compliance, despite the fact that at the present time much of the gasoline does not comply with existing standards as shown by the recent reports of the Bureau of Mines. The characteristics of gasoline now supplied were believed to be the result of the freedom in practice which is possible rather than the result of any necessity.

Gasoline Specifications

The original motor-gasoline specifications proposed by the committee in October, 1918, were revised and a new form made effective Nov. 25, 1919. This revised specification provides for a distillation test as the chief requirement. Refiners present agreed that careful preparation of gasoline to comply with the specifications in the proposed modified form would permit large increases in output. It was stated that small refiners could increase their output by more careful plant operation, since the same bad plant practice which gives a high maximum temperature in distillation also results in leaving a larger percentage of gasoline in the higher oils than is necessary or desirable.

It is evident that the committee will take pains to increase the definiteness and simplicity of the specifications as to how the distillation test will be made. The committee feels that it is even more important to have uniform and significant methods of testing than it is to get exactly uniform specifications. No conclusion was indicated by the committee nor was a general agreement in opinion of the refiners evident on the question of the number of olephines permissible in a cracked gasoline.

Navy Fuel-Oil Specifications

It was proposed that the specifications for navy fuel oil, which now are based largely upon the specific gravity tests, should be changed and viscosity of the oil substituted as the important criterion. It was pointed out that a 16 deg. Bé. fuel oil made from Pennsylvania crude could not be handled in any way except with shovels because of its very high viscosity. Agreement seemed to be unanimous that the gravity means even less with fuel oils than with motor gasoline, and that the viscosity requirements should be chosen to be those corresponding to the fuel oils now received by the Navy under grades A, B and C, these being made from Mexican crude.

It was agreed that the viscosity requirements should be based upon tests with the new type of Saybolt fuel-oil viscosimeter used at 122 deg. F. This is the temperature for which this apparatus is commonly built for testing road oils; at this temperature it gives results in from seven to ten minutes, which cannot be obtained in less than two or three hours with the older types of viscosimeter.

Diesel-Oil Requirements

It was pointed out that the present requirements of no asphaltum in gas oil for Diesel engines have no real significance, as there is no means of knowing either what this signifies or how to test for asphaltum. The question was discussed at length as to whether a distillate oil was essential for this work, and it was pointed out that in general distillate oils burn cleaner than crude residues. The committee indicated that some adjustment of this specification would be made after further consideration.

Requirements for Lubricants

The question of color requirements for lubricants raised some criticism of present specifications, and it was recommended to the committee that they consider transparency rather than color as the important factor. For this purpose the transparency of a quarter-inch layer should be sufficient to enable one to read ordinary print through it, according to one suggestion made.

The refiners emphasized particularly that cup-grease specifications should make no distinction between animal fats and vegetable fats nor between animal fats and fatty acids. The present requirements permit only pure animal fats for use in blending these greases, and it is believed that this would result in prohibitive cost if attempted. As a matter of fact, it is practically impossible to tell after blending what has been used, and in general the use exclusively of animal fats is no longer practiced.

Specifications now include provisions for a variety of miscellaneous lubricants, among which are the following: Aircraft machine-gun oil, buffer oil, transmission lubricant, steam-cylinder oils, compounded steam-cylinder oils, chain or wire-rope lubricant, gun and ice-machine oil, hydroline oil, aëro and motorcycle oil, marine-engine oil and oil and grease for the recoil mechanism of guns. It was pointed out that most of the specifications for these materials were very satisfactory. The large steam-evaporation losses from certain compounded cylinder oils were discussed, but no modification in specification was recommended as a remedy.

Progress Being Made in Adopting the A. S. M. E. Boiler Code

The administrative council of the American Uniform Boiler Law Society in its annual report has given encouraging news of its efforts for the adoption of the A. S. M. E. Code in the various states. These efforts have consisted in presenting the matter before the officials of different states, explaining the provisions of the code, smoothing out misunderstandings and giving out information of value to those interested. In regard to legislation, however, it was pointed out that only five state legislatures other than those which have already accepted the code have convened this year; it has been what might be termed an off year in legislation.

An interesting development is that the code is coming into general use in colleges and universities. The following universities now use it as a textbook: Massachusetts Institute of Technology, Sheffield Scientific School, Yale University, Armour Institute of Technology (Chicago), Case School of Applied Science (Cleveland), University of Vermont, University of Cincinnati, Johns Hopkins University (Baltimore), University of Michigan, University of Minnesota, Rensselaer Polytechnic Institute, Rutgers College and University of Texas. The code is being used as a reference book at the following universities: Vanderbilt University (Tennessee), New Mexico College of Agriculture and Mechanic Arts, Tulane University of Louisiana, University of Colorado, University of Washington, University of Maine, University of Wyoming, Virginia Polytechnic Institute and Washington University (St. Louis).

This is a most promising sign as it means that young men who will be engineers a few years hence will be conversant with boiler code practice; hence the adoption of the code should become a natural and easy step.

Progress in Several States

In Indiana there had been certain restrictions placed upon boilers which practically eliminated uniformity. This question was taken up in November, 1919, with the Industrial Board and the chief inspector, with the result that the board removed the restrictions and agreed to accept the A. S. M. E. Code in full.

In the same month a misunderstanding arose in California over the specifications that were required for boilers during the war period. The chairman of the Boiler-Law Society's committee, Charles E. Gorton, entered a conference with the state officials and two of the largest boiler manufacturers on the coast, upon their request. After a discussion covering several days the question was satisfactorily settled; and it was due to that fact that these two prominent manufacturers have since co-operated with the society so that it was possible to secure the adoption of the code in the state of Oregon.

On his way back from this conference in California Mr. Gorton stopped off in Little Rock, Ark., and had a meeting with the Hon. Thomas A. Wilson, State Labor Commissioner, and J. D. Newcomb, Jr., State Boiler Inspector. The outcome of this was that on March 1 Arkansas adopted the code and put it into full effect.

Progress has been made in Virginia in the way of collecting facts and figures relating to the boiler situation, although it has not yet been considered advisable to introduce a bill. Recommendations are being prepared for the coming session of the legislature.

Although it was declared impossible to secure a statewide law in Maryland such a law was introduced and passed, the provisions of which for the organization of the Board of Boiler Rules are to go into effect Jan. 1, 1921.

The state of Washington is expected to adopt the code within the next few months, and the city of Seattle has already done so.

There are now seventeen states which have adopted the A. S. M. E. Boiler Code, and of these Oregon, Utah, Arkansas and Maryland have been added this year. Eleven cities also now use the Code, Scranton and Seattle having accepted it this year.

Progress is being made in reconciling the more important points of difference between the Massachusetts Rules and those of the A. S. M. E., as reported in the account of the semi-annual hearing, elsewhere in this issue.

Power Scarcity a Factor in Electric Heat Treatment

Electric heat treatment was the subject discussed by the members of the Philadelphia Section, Association of Iron and Steel Electrical Engineers, at the Engineers' Club, Philadelphia, Nov. 6. A. J. Standing, section chairman, in opening the meeting, pointed out that the successful development of electric heat treatment required large quantities of cheap power, and the tying together of power plants will assist materially in accomplishing this end. The wide application of electric heat treating was explained by G. P. Mills, who also with lantern slides showed the construction of modern furnaces, method of control, etc. The control for electric furnaces has been developed to a state where it is possible to automatically maintain the temperature at within ¼ of 1 per cent of that required. An electric furnace is an ideal load for a power plant since it is balanced and has a high power factor and in many cases they can be used as off-peak loads. These furnaces have a thermal efficiency as high as 90 per cent and have been constructed for temperatures up to 1,800 deg. F. Power consumption ranges from 40 to 225 kw.-hr. per ton of metal treated.

J. E. Wilson told of his experience using oil for heat treating and expressed the opinion that the electric furnace was to be preferred to the oil-heated furnace. Mr. Wilson's experience had been with both the low-pressure and high-pressure type of furnaces, and he thought that there was a little preference between the two types. With the oil-type furnace it has been found necessary to reline it twice a year; the temperature is not easily controlled; care must be taken to have complete combustion; the furnaces are very hot to work around, especially in the summer time, and they are not all that could be desired from a safety-first standpoint. With oil at 15c. per gal. cost of heat treating was given ranging from 0.6 to 2.4 mills per pound of product treated.

In his paper J. R. Brown discussed the application of electricity to heating rivets. The electric rivet heater consists of a transformer having one turn in the secondary arranged so that the two ends of this turn are closed by placing the rivet in circuit. In heating rivets, as in heat treatment, the electrical method has many advantages over other methods. It is easily moved from one location to another, is sanitary, is easy of operation, etc. It has been found that the power consumption per 100 lb. of rivets heated is 14 kilowatt-hours.

Considerable discussion was centered on the possibility of obtaining power at this time for operating electric heat-treating furnaces, it being argued by some that there was a real power shortage and that burning a few tons of coal was an easy way to solve the heat-treating problem. Others pointed out that going around to the users of electric furnaces did not show any scarcity of power. As an illustration of the development in electric furnaces attention was called to those installed in 1913. To keep these in shape for operation took more time than they were in service, whereas the present furnace gives practically no trouble. In presenting the central-station side of the question, the opinion was expressed that the electric furnace load was a favorable one.

With the object of determining the possibilities of alcohol as a motor fuel the Empire Motor Fuel Committee of the Imperial Motor Transport Council, in England, has recently appointed small technical committees to consider the modification of custom and excise regulations pertaining to alcohol; to experiment for determining the best conditions for developing the alcohol engine, and the types of alcohol pure, alone or in mixture best suited for industrial purposes; and to develop methods of denaturing alcohol; that is, rendering it unpotable.

Coal Production Continues High

Production of soft coal during the week ending Oct. 30 not only continued above the 12,000,000-ton mark, but rose quite appreciably, according to the weekly report just received from the Geological Survey. In fact, a new maximum for the year was established by the total for the week of 12,338,000 net tons. This was 97,000 tons more than the preceding week, and except for the corresponding week of October, 1919, which was just before the great coal strike, has not been exceeded since the Armistice. It is predicted that production for the week ended Nov. 6 will fall considerably below this, on account of Election Day and religious holidays.

Reports showing the percentages of full-time output have been delayed, so that the latest figures available on that phase of the question are for the week ending Oct. 23. According to these figures, which are fairly representative of the country as a whole, losses attributed to labor amounted to 7 per cent of full time, out of a total loss due to all causes of 31.9 per cent. Transportation disability was the most important of all, causing losses of 20.8 per cent. The week was marked by an improvement in car supply, notably in West Virginia.

The Geological Survey bases its figures upon statements received from about 3,000 mines, which represent approximately 60 per cent of the total capacity of the country.

The *Bituminous Coal Bulletin* of the Federal Trade Commission for June, just now received, covers reports from only 555 operators, but contains some interesting figures on costs. There is some doubt as to whether these data are truly representative, as so few operators have reported; but it seems probable that the costs of those who refused to report are no greater, and possibly lower, than the costs of those who responded. Accordingly, they are presented here for what they are worth, together with corresponding figures for the year of 1918. The first number in each set given here represents the cost per ton for the year 1918, and the second is for the month of June, 1920: Labor cost, $1.49 and $2.02; supplies, $0.26 and $0.31; general expenses, $0.29 and $0.37; total cost, f.o.b. mine, $2.04 and $2.70; sales realization, $2.65 and $3.44; making a "margin" of $0.61 and $0.74. It should be remembered that margin is not profit, for selling expenses, interest, etc., must be deducted from it before the actual profit may be found.

As announced in *Power* last week, these bulletins of the Federal Trade Commission are to be suspended until the courts decide whether the commission can force operators to turn in reports instead of requesting it, as at present.

Semi-Annual Hearing of Massachusetts Board of Boiler Rules

The semi-annual hearing of the Massachusetts Board of Boiler Rules was held at the State House, Boston, on Nov. 4. John H. Plunkett, chief of inspections of the Department of Public Safety, of which department the boiler-inspection service became a part in the recent reorganization, is, by virtue of his office, chairman of the board, and presided at the hearing. The other members present were: Frederick A. Wallace, representing the boiler-using interest; Henry H. Lynch, representing the boiler-manufacturing interest; and John A. Collins, representing the boiler-insurance interest.

Mr. Plunkett explained that the purpose of the present hearing was a dual one—first, to hear petitions from those who desired changes in or interpretations of the Rules, and second, to submit for public discussion changes in the Rules which had been proposed on the initiative of the board itself, copies of which proposed changes had been published and made available to those interested.

The only petitions to appear under the first division of the program were the Buffalo-Springfield Road Roller Co., in reference to the location of the stamp upon their boilers, and the Keystone Driller Co., petitioning for the favorable consideration of the Porcupine Boiler which they manufacture.

The principal changes proposed by the board were the adoption of specifications for boiler-plate steel, boiler-rivet steel, staybolt steel, steel bars, steel castings, gray-iron castings, malleable castings, boiler-rivet iron, staybolt iron, wrought-iron bars and lap-welded and seamless boiler tubes. These specifications are, for the most part, those of the American Society for Testing Materials, which is the highest authority upon the subject, and as these specifications of the A. S. T. M. are used in the Boiler Code of the American Society of Mechanical Engineers, their adoption by the Massachusetts Board of Boiler Rules reduces the points of difference between these two codes. There were no engineering considerations urged against the adoption of the proposed changes, the only opposition being from Massachusetts boiler manufacturers who stigmatized the revision as "an entering wedge for the A. S. M. E. Boiler Code," to any attempt in the direction of uniformity with which they appear to be implacably opposed.

French Hydro-Power Plants for the Rhine

The Comité économique regional de l'Est has submitted to the French government plans for the exploitation of the water power of the Rhine. These plans have been approved and will in the course of the near future be put into operation. It is proposed to build ten power plants between Hüningen and Strassburg, each estimated at 80,000 hp. As Switzerland has certain rights relating to navigation on the Rhine, the plants will necessarily be erected some distance from the banks. The plans provide for a canal running parallel to the Rhine, which will feed the power stations. The total cost is estimated at 350,000,000 francs, but will probably be very much higher. The power thus obtained will be used for supplying the mining district of the French East, especially the Briey district.

The Versailles peace treaty provides that the water power of the Rhine along the German-French frontier is common property of both countries. In the case of new power plants the country building them has to recompense the other country up to half of the value of the produced power either by supplying power or by the money equivalent.

The Engineer, of London, reports a recent economizer explosion that was caused by improper handling. The economizer, which was in reasonably good condition, was used to heat feed water for three Lancashire boilers, and the flues were so arranged that the gases could be bypassed directly to the chimney. The accident was evidently caused by a sudden change in the temperature of the economizer tubes, which took place when the engine was started up in the morning. Just previous to this while the steam pressure was being raised but no demands made on the boilers, the economizer undoubtedly became very hot. When the engine was started, the feed pump, which was belt-driven from the main engine, forced the cold water into the economizer. The resultant contraction of the tubes cracked them, and they blew up under the steam pressure. The proper way to handle the plant would, of course, have been not to pass the hot gases from the fires through the economizer until feed water was needed by the boilers, and it might even be necessary, on account of leaky dampers, to keep down the temperature of the economizer during the night by giving it a little feed water. Added to these considerations it would be better, for the sake of economy in coal and for the prevention of external corrosion of the economizer tubes, if the feed water was warmed before being led to the economizer in the ordinary course of working.

That the coal situation is improving, in the opinion of the Interstate Commerce Commission, is shown by the order releasing 25,000 open-topped cars from the coal trade. Certain cars suitable for handling steel, sand, gravel, and other building and road materials were released from the coal priority order on Nov. 6. The cancellation of the Lake order and the maintenance of production in excess of 12,000,000 tons a week are doing a great deal to relieve the general situation.

Specific Heat and Dissociation in Internal-Combustion Engines

At the meeting of the Engineering Section of the British Association Committee on Gaseous Explosions, on Aug. 25, a paper relating to the subject of specific heat and dissociation in internal-combustion engines was presented by H. T. Tizard and D. R. Pye.

In this paper it was pointed out that the British Association Committee on Gaseous Explosions devoted a good deal of attention before the war to the question of the specified heat of the working fluid and the possible effects of dissociation of carbon dioxide and water vapor at high temperatures. Unfortunately, this work was interrupted by the war, and there had been in recent years very little advance in the thermo-dynamical theory of internal-combustion engines. On the other hand, there had been great practical advances, and the actual efficiency of a modern high-speed engine was higher than the theoretical efficiency calculated on the old specific heat figures of Clerk and Langer, even if no allowance was made for loss of heat. The relative advantages of different fuels, increase in efficiency to be expected from an increase in compression ratio, and the reasons for the change in power with different "mixtures" were, said the authors, all problems which had not yet been satisfactorily solved. For these reasons the authors were led to take up the subject afresh.

Calculating Thermal Efficiency from Specific Heats

A method for calculating thermal efficiency from a knowledge of specific heats was worked out very completely by the late Professor Hopkinson in his paper on "The Thermal Efficiency of Gas Engines," but all work on these lines had suffered under two great disadvantages: (1) The specific heats of the gases concerned were not known at all accurately above 1,500 deg. C.; (2) the dissociation of CO_2 and H_2O in the cylinder was unknown, and no attempt had been made to separate the two effects of specific heat and of dissociation. As to the first point, there was ample evidence that the maximum temperature reached in a petrol engine was of the order of 2,500 deg. C. As to the second point, the Committee on Gaseous Explosions pointed out rightly that it was the "apparent" specific heat that was of primary importance for the theory of engine efficiency, and this included any effects of dissociation. But as the dissociation of CO_2 and H_2O was accompanied by an increase in the number of molecules, its extent depended considerably upon the pressure as well as the temperature. Further, since they had one dissociation product in common—namely, oxygen—dissociation in a mixture of the two was not the same as when they were separate; the extent of the dissociation of each would in fact depend on the ratio of the amounts present, and the "apparent" specific heat of a mixture might be very different to the sum of the "apparent" specific heats of each measured separately. The only possible way to attack the problem was to find the true specific heats and to measure the dissociation under definite conditions, from which it was possible to obtain sufficient data to calculate equilibrium conditions in any mixture. Sufficient data, we were reminded, already existed for this purpose. It was assumed in the first place that the only molecular species present after an explosion and during the expansion were CO_2, H_2O, CO, H_2, O_2, N_2, and at the high temperatures reached the reaction velocity was such that chemical equilibrium was always maintained throughout the working stroke. There was considerable evidence in favor of the substantial accuracy of this assumption. Mixtures of pure benzene with air were the subject of experiment. It was shown that the power curve should show a sharp maximum when benzene was present in the correct proportion for complete combustion to CO_2 and H_2O and should fall off steadily for both weaker and rich mixtures. This was contrary to observations, which in itself was evidence of "dissociation." When dissociation was taken into account it was shown that the power should remain constant to within about 1 per cent for mixtures ranging from the correct mixture to about 30 per cent rich mixtures. This was entirely confirmed by experiment. It was further predicted that the same curve of an engine running on a paraffin mixture should fall off more sharply with the richness of mixture than if benzene were used This had also been confirmed by experiments on Mr. Ricardo's experimental engine.

Maximum Thermal Efficiencies with Weak Mixtures

Maximum thermal efficiencies in practice were obtained with mixtures so weak that any further weakening resulted in misfiring. Experiments by Watson and others had shown that that occurred when the amount of fuel present was only about 80 per cent of that required for complete combustion of the air. It was shown that if the compression ratio were 5 to 1 the theoretical efficiency, if there was no heat loss, should be 38 per cent of the heat of the fuel. Indicated thermal efficiencies as high as 70 per cent of the "air cycle efficiency"—equal to 33 per cent—were said to have been obtained in engines working at this compression ratio. The highest thermal efficiency under these conditions that the authors had been able to obtain was 32 per cent of the heat of the fuel. The difference between the calculated and observed values corresponded to a loss of heat during the working stroke of about 13 per cent of the heat of the fuel. Since the total loss of heat to the cylinder jackets was found to be about 25 per cent the correspondence between calculated and observed values must be considered very satisfactory. It was interesting to note that with weak mixtures the theoretical efficiency was about the same whether the gases were assumed to be dissociated or not. The effect of dissociation—which was about 20 per cent of the CO_2 present at the maximum temperature—was to lower the maximum temperature without affecting appreciably the work done on expansion. The maximum temperature for a benzene-air mixture was 2,700 deg. C., but was much lower for a paraffin-petrol-air mixture.

As regarded maximum power with different fuels, it was shown that when all factors were taken into account the maximum power with perfect distribution should be the same within 1 per cent for any kind of hydrocarbon fuel, if the initial charge temperature—or volumetric efficiency—and the compression ratio were constant. The maximum power with alcohol should be slightly lower, but as the latent heat of alcohol was high the charge temperature in practice was lower, and the maximum power reached the same as, or slightly higher than, that reached with hydro-carbon fuels. These conclusions had also been confirmed by experiment. Finally, it was shown that no other gases besides N_2, O_2, H_2, CO, CO_2, H_2O could exist in appreciable quantities in equilibrium during the explosion and expansion stroke. Methane could be formed during the exhaust stroke, and also aldehydes if the mixture was rich. The ratio of carbon monoxide to hydrogen in the exhaust gases under different conditions could be calculated. If a paraffin petrol was used the ratio H_2/CO was calculated as 0.4, whereas Bannatyne's empirical rule gave 0.36. With aromatic fuels this ratio would be very different.—*The Engineer.*

All restrictions against the use of power, except skip stops in the operation of street railways, have been removed recently by the California state power administrator, H. G. Butler. Recent rains have made possible the lifting of the ban, and there will be no return to the restrictions unless there is a dry fall. In this event the power companies and the public will again be placed on a limited allowance of electricity. The present order, however, does not relieve the power companies from the necessity of operating their steam plants to capacity. There is still need for steam-generated power, the recent rains being sufficient only to relieve the immediate strain.

The American consul at Newcastle, New South Wales Australia, reports that the total amount of coal mined in that district in September was 468,000 tons, of which 117,600 tons was exported overseas; the remainder was for Australian consumption.

Water Power Applications

Additional applications have been made to the Federal Power Commission for preliminary permits as follows (the serial number, the name and address of the applicant, the type of project works, their location, and the use to which they are to be put are shown):

73. J. G. Van Zandt, care W. L. Huber, First National Bank Building, San Francisco; Bear Creek and Santa Anna Creek, Cal.; reservoirs, conduit and power house; purpose, not given.

74. Electro-Metals Co., care W. G. Devereaux, 729 Call Building, San Francisco; dam, reservoir, tunnels, penstocks, power house; Salmon River; reduction of ores.

75. R. G. McDonald, Williams, Cal.; two power plants, reservoir, conduits; Convict Creek, Inyo Forest Reserve; mines, mills, pumping.

76. J. Harvey Pierce, 4838 Elmwood Ave., Los Angeles; three dams, three power houses; Mammoth Creek, Inyo Forest Reserve; mining and lighting.

77. Snow Mountain Water & Power Co., Standard Oil Building, San Francisco; two dams, conduits, reservoir, location not shown; public utility.

78. Western States Gas & Electric Co., Stockton, Cal.; enlargement American River conduit; South Fork, American River, El Dorado National Forest, Cal.; public utility.

79. William C. Albertson and Stephen L. Mershon, care Fort, Hunt & Shipman, Newark, N. J.; dam and power house; Delaware River at Foul Rift, two miles south of Belvidere, N. J.; use not stated.

Amazon-Dixie Mining Co., Wallace, Idaho; license; to construct transmission line over Lolo National Forest, Montana; use, mining.

Granite Falls Manufacturing Co., Granite Falls, N. C.; preliminary permit; dam, reservoir, conduit, power house, and transmission line on Wilson Creek, Caldwell County, North Carolina; use, public utility.

Alabama Power Co., Birmingham, Alabama; license; dam, power house and transmission line; Coosa River, at Duncan's Riffle, Ala.; use, uublic utility.

Paving Granite Quarry Co., Rapid City, S. D.; license; transmission line in Black Hills National Forest Preserve; use, quarrying.

Town of Ronan, Mont.; preliminary permit; dam, power house and transmission line; Crow Creek, Mont.; use, public utility.

Information About the State License Board

Engineers throughout New York State have for some time been anxious to know the names of the members of the new state board which is to have charge of granting licenses to professional engineers and land surveyors. **Power** has been able to secure these names from an authoritative source and presents them herewith. The members of this board have been selected with the object of providing representation for every important branch of the engineering profession. Their names, together with the branches which they represent, are: For mechanical engineering, Virgil M. Palmer, of the Eastman Kodak Co., Rochester; civil engineering, Col. W. J. Wilgus, consulting engineer, of New York City; mining engineering, Major Percy E. Barbour, consulting engineer, of New York City; electrical engineering, H. A. Reist, of the General Electric Co., Schenectady; electro-chemical engineering, A. H. Hooker, of the Hooker Electro-Chemical Co., Niagara Falls. The board's first meeting is set for Nov. 23.

A summary of the law through which this board will operate follows. It has been condensed from a longer abstract prepared by Engineering Council.

A candidate for an engineering license must have had at least six years of active professional engineering work, one of which shall have been in responsible charge, of a character satisfactory to the board. At least four years of active engagement in land-surveying work are required of a candidate for a surveyor's license. Each two years of study of engineering in an engineering school of standing satisfactory to the board, however, will be considered as equivalent to one year of active practice. A candidate for the surveyor's license must be a citizen of the United States or must have declared his intention of becoming one; this provision does not apply to engineers. The applicant must be at least 21 years of age, of good character and repute, and to practice surveying, must speak and write the English language. Candidates may be required, however, to furnish further evidence, which may include the result of a required examination. The fee for either license is $25, and for license to practice both engineering and surveying is $35.

Two years after the act takes effect, no county, city, town or village, or other political subdivision shall engage in construction or maintenance of any public work involving professional engineering or land surveying for which plans, specifications and estimates have not been made by, and construction and maintenance supervised by, a licensed engineer or land surveyor, unless the expenditure for the completed project is less than $2,000. Plans, specifications, plats and reports may be stamped with a seal the design of which shall have been approved by the board. State and municipal employees are exempted only until their term of office expires. Employees of the United States are entirely exempt. A non-resident may practice in this state if he is legally qualified for professional service in his own state or county, where the necessary qualifications meet the requirements of the board. He may practice for such reasonable time as the board requires for considering his application for a license. The board may revoke a license for cause only after a hearing at which the accused has the right to be represented by counsel, to introduce evidence and to examine and cross-examine witnesses. Penalties for violation of the law, after it has been in effect for two years, may be a fine of between $100 and $500, imprisonment for three months, or both.

The law covers all those practicing or offering to practice professional engineering or land surveying in a supervisory capacity.

A. S. C. E. Votes Against Joining Federated American Engineering Societies

A referendum vote of the members of the American Society of Civil Engineers on the question of accepting membership in the Federated American Engineering Societies has resulted in the defeat of the proposition by a vote of 3,278 to 2,330. The total number of votes was therefore 5,608, representing 57 per cent of the membership, which is 9,773.

For some time a small group in the society has been very active in its opposition to the Federated American Engineering Societies and has been circularizing the members of the A. S. C. E. and spreading propaganda in a way that now appears to have been very effective. While this vote is subject to review by the society's council, it is doubtful whether that body will reverse the expressed instructions of a majority of the members.

The civil engineers have always been extremely conservatice; it will be remembered that it was only a few years ago when they finally joined the other three so-called Founder Societies and moved into the Engineering Societies Building. It is to be hoped that here again better judgment will eventually prevail.

City Engineer M. M. O'Shaughnessy, of San Francisco, has announced that plans for the city's new $6,000,000 electric power plant at Hetch-Hetchy are under way, and that construction of this plant may be followed by the establishment of auxiliary plants at other points. The main plant is to be built at Priest's Hill, where the water will have a sheer drop of 1,200 ft. and 400,000,000 gal. of water a day will pass through the weirs to the turbines. It is expected that 66,000 hp. can be developed.

The London *Morning Post* for Sept. 2 published some particulars of a very important oil transaction in Rumania. The Anglo-Persian Oil Co., allied with some other British and foreign financial interests, has acquired the control of one of the large oil properties in Rumania. It is expected that a company will be floated with a capital of more than £2,000,000.

Personals

Ralph T. Bratt has left Olney & Warrin, Inc., and is now employed in the industrial department of the Locomotive Superheater Co., New York.

David S. Wegg, Jr. has left the Allis-Chalmers Manufacturing Co. to become associated with W. A. Gilchrist, of Chicago, as electrical engineer.

H. M. Lowenstein, formerly designer with the De La Vergne Machinery Co., is now designer for the Babcock & Wilcox Co., Bayonne, N. J.

A. Pohlman, well known in the combustion field, is now with the engineering department of the Diamond Power Specialty Co., Detroit, Mich.

Elias Schlank has opened offices in Newark and is prepared to advise silk manufacturers and allied industries on engineering problems pertaining to plant operation and maintenance.

Wallace H. Martin has resigned as associate professor of mechanical engineering at the Pennsylvania State College and is now professor of heat engineering at the Oregon Agricultual College.

John Breslau, formerly sales engineer, manager of publicity and production manager of the Terry Steam Turbine Co., of Hartford, Conn., is now owner of the J. B. Engineering Sales Co., of Hartford.

James D. Mooney, until recently assistant to A. P. Sloan, Jr., vice president of the General Motors Corporation, has been made general manager of the Remy Electric Division of that corporation, Anderson, Ind.

Webster Tallmadge, who has been connected with the Westinghouse Electric and Manufacturing Co., South Philadelphia Works, Lester, Pa., is now manager of the Power Division, Thomas A. Edison Industries, Orange, N. J.

Robert Lacy announces his resignation from the Geo. T Ladd Co, Pittsburgh, and appointment as sales engineer by the Rush Machinery Co., Pittsburgh, to act as representative for steam equipment specialties and water-tube boilers.

W. H. Moore has resigned as chief operating engineer of the electric plant of the Society for Establishing Useful Manufactures, at Paterson, N. J., to accept the position of chief engineer of Dartmouth College, Hanover, N. H.

Mayo D. Hersey, who for over ten years has been a physicist at the United States Bureau of Standards, and recently chief of the Aëronautic Instruments Section, Washington, D. C., is now with the Massachusetts Institute of Technology, as associate professor of Properties of Matter in the Department of Physics

Thomas B. Wilson has been appointed steam engineer in charge of the newly organized department of steam enginering at the plant of the Bethlehem Steel Co., Sparrows Point, Md. He was formerly steam engineer for the Cambria Steel Co. and for the past two years has been on combustion work for the Du Pont Co., Wilmington, Del.

Society Affairs

The American Society of Civil Engineers is to hold a meeting Nov. 17, at 8:30, at its rooms in the Engineering Societies Building, New York City. The subject will be "Urban and Suburban Passenger Transportation."

Memorial Exercises for Dr. Samuel Sheldon are to be held in the main auditorium of the Engineering Societies Building, New York City, on Nov. 17, 8:30 p.m. Arthur W. Berresford, president of the A. I. E. E., will preside, and will introduce the following speakers: William N. Dickinson, Bancroft Gherardi, Dr. Arthur E. Kennelly, T. Commerford Martin and Dr. William H. Nichols.

The Chicago Section of the A. S. M. E. will celebrate the fortieth anniversary of the society on Nov. 22 in the auditorium of the Western Society of Engineers, Monadnock Building, at 7 p.m. Short addresses will be made by Herbert S. Philbrick and Captain Robert W. Hunt, after which Dr. G. O. Smith, director of the United States Geological Survey, will speak on "Industries' Supply of Energy."

American Engineering Council, the governing body of the Federated American Engineering Societies, is to hold its first meeting on Thursday and Friday, Nov. 18 and 19, at the New Willard Hotel, Washington. Thursday morning will be devoted to registration, appointment of committees and other preliminary business, and the afternoon to an address by J. Parke Channing, followed by discussion of the field of activity for the societies. On Friday reports will be received from committees, and the election of permanent officers will take place. Friday evening Herbert Hoover will make an address, after which an informal reception and smoker will be held.

Business Items

The J. B. Engineering Sales Co. has been appointed Connecticut sales agents of the Conveyors Corporation of America, formerly American Steam Conveyor Corporation. Offices are at 60 Prospect St., Hartford, Conn.

The Powers Regulator Co., of Chicago, which began business in 1890 in a 12 x 16-ft. room, has recently moved into its new factory, a fireproof building containing 40,000 sq.ft. of floor space. The company manufactures a line of temperature-regulating apparatus for use in heating processes and the heating of rooms

The Monarch Soot Remover Co., Inc., of Troy, N. Y., having closed its Troy factory, has established a new machine shop and brass foundry in Wollaston, Mass., and has incorporated under the laws of Massachusetts. Bradford L. Ames, of Boston, is the president, and Leonard W. Newell, treasurer of the Wollaston Foundry Co., is the treasurer.

Trade Catalogs

The Packard Electric Co., of Warren, Ohio, has issued a bulletin on "Metering Transformers" in which are described the weatherproof and switchboard types of the single- two- and three-phase potential and current transformers. The weatherproof, or outdoor type of oil-insulated transformer, has been developed in compliance with the demand from the central manager, who is anxious to avoid the building of a housing to protect the transformers from the weather.

New Construction

PROPOSED WORK

Me., Old Town—The Bangor Ry. & Electric Co., 90 Harlow St., Bangor, plans to build a 2 story, 70 x 75 ft. pumping plant and substation, here. Crowell & Lancaster, Exchange Bldg., Bangor, Archts.

Mass., Boston—The American Can Co., 120 Bway., New York City, plans to build a factory here, including a steam heating system. About $250,000.

Mass., Charlestown—The Charlestown Terminal Bldg. Co., 27 State St., Boston, will soon award the contract for a 7 story, mercantile building including a steam heating system on City Square, here. F. O. Lewis, 50 Bromfield St., Boston, Archt. and Engr.

Mass., Springfield—The Masonic Hall Assn., Masonic Bldg., is having plans prepared for a Masonic Temple on State St. About $750,000. E. A. Blodgett, Pres.

Conn., Hartford—The Conn. Gen'l. Life Insurance Co., 64 Pearl St., is having plans prepared for a 6 story office building including a steam heating system on Elm St. James Gamble Rogers, 367 Lexington Ave., New York City, Archt. and Engr.

Conn., Newington—The Conn. Children's Aid Society, 926 Main St., Hartford, plans to build a new 1, 2 and 3 story children's home, here. About $500,000.

N. Y., New York—The Missionary Sisters of the Sacred Heart, c/o St. Lawrence Hospital, 457 West 163d St., plan to build a 6 story, 165 x 228 x 244 ft. hospital on Edgecomb Ave. between 163rd and 164th Sts.

N. Y., New York—Dept. Pub. Wks., Albany, received bid for the installation of a steam heating system in the Barge Canal Terminal headhouse at Pier 93, West 53d St., here, from the Austin Engineering Corp., 121 West 42d St., at $4,875.

N. J., Atlantic City—The City will soon award the contract for a 3 story fire house including a steam heating system. About $250,000.

N. J., Vineland—The State plans to build a 40 x 64 ft. power plant here, including 2 boilers. About $21,500. F. H. Bent, 142 West State St., Trenton, State Archt.

Pa., Altoona—The Catholic Diocese of Altoona, c/o Rt. Rev. Bishop John J. McCort, 1211 13th St., is planning for a 100 x 150 ft. cathedral on 12th Ave. About $1,000,000. Archt. not selected.

Pa., Franklin—The Franklin Exch. Nat'l. Bank will soon receive bids for a 3 story, 100 x 100 ft. addition to bank including a steam heating system. W. L. Stoddart, 9 East 40th St., New York City, Archt. and Engr.

Pa., Freemansburg—The New Jersey Zinc Co. plans to install additional motors, make changes in power equipment and in the method of firing boilers, etc.

Pa., Philadelphia—The Hotel Walton Co., R. W. Goelet, Pres., Broad and Locust Sts., is having plans prepared for a 20 story, 70 x 130 ft. hotel and store building including a steam heating system on Broad St. About $1,700,000. A. M. Gray, 1402 Bway., New York City, Archt. and Engr.

Md., Aberdeen—The Constructing Quartermaster, Aberdeen Proving Grund, will receive bids until Nov. 18 for a generator house, steam heating system, etc.

Md., Baltimore—The Ed. of Awards received lowest bid for a 3 story, 76 x 271 ft. school at Fort Ave. and Latrobe Park from the Standard Constr. Co., 1713 Sansom St., Philadelphia, Pa., at $485,000. Contract for steam heating plant will be sublet. O. G. Simonson, Maryland Casualty Tower, Baltimore, Archt. H. F. Adams, Calvert Bldg., Engr.

D. C., Bellevue (Washington P. O.)—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., plans to install a turbo-generator, switchboard equipment and a reciprocating air compressor, here.

W. Va., Bluefield—The Baptist Educational Comn. plans to build a college consisting of 18 buildings. About $750,000. Archt. not yet selected.

N. C., Smithfield—The City plans to build a 4 story, 79 x 117 ft. court house including a steam heating system on Market St. About $500,000. Harry Barton, Greensboro, Archt

Fla., Fort Myers—Peter Schutt and associates, Bradford Hotel, are having plans prepared and will receive bids early in December for a 3 and 5 story hotel including steam heating and pumping plants on McGregor Blvd. Cost between $400,000 and $500,000. F. J. Kennard, American Bank Bldg., Tampa, Archt.

Fla., Jacksonville—The Wilson-Toomer Fertilizer Co., Viaduct, is having plans prepared for a new plant. About $1,000,000. N. M. G. Prange, Mgr.

Ala., Tuscaloosa—D. O. Whilldin, Archt., Title Guaranty Bldg., Birmingham, will receive bids until Dec. 15 for a 107 x 235 ft. dormitory and the first units of a power house, laundry and other buildings for the Alabama Home for the Feeble Minded, here. About $163,000.

La., New Orleans—The American Can Co., 120 Bway, New York City, plans to build a factory including a steam heating system, here. About $250,000.

O., Ashtabula—The City voted on $1,000,000 bonds for a new electric light and power plant.

O., Cincinnati—The Business Men's Club, 9th and Race Sts., is having plans prepared for a 9 story, 150 x 200 ft. club house at 8th and Race Sts. About $1,000,000. Samuel Hannaford & Sons, 6th and 9th Sts., Archts.

O., Cleveland Heights (Warrensville P. O.)—The Bd. Educ., c/o E. K. Bryan, Lee Rd., will receive bids until Nov. 24, for a 2 story, 50 x 67 ft. power plant. F. C. Warren, Hippodrome Bldg., Cleveland, Archt., L. A. Quayle, 1455 West 98th St., Engr. Noted June 8.

O., Huron—The City voted on $42,000 bonds for improvements to the electric light plant.

O., Kent—The Bd. Educ. is having plans prepared for a 2 story, 160 x 200 ft. high school. About $275,000. Mills & Millspaugh, 67 East Long St., Columbus, Archts.

O., Lakewood (Cleveland P. O.)—Bd. Educ., G. Grill, Clk., Warren Rd., plans to build a 2 story school including a steam heating system. About $250,000. C. W. Hopkinson, 900 Rose Bldg., Cleveland, Archt.

O., West Park—The Bd. Educ. plans to build a 3 story high school including a steam heating system. About $1,000,000. F. W. Featherstone, Clk.

Ind., Elkhart—The Wawasee Tire & Rubber Co. is receiving bids for a 4 story, 175 x 175 ft. factory including a steam heating plant. About $500,000. R. L. Simmons, Archt.

Mich., Detroit—The Detroit Art Museum, Jefferson Ave. and Hastings St., plans to build a 1 and 2 story, 150 x 300 ft. art museum including a steam heating system on Woodward, Kirby, Farnsworth and John Sts. About $2,000,000.

Mich., Detroit—The Central Christian Church, c/o John De Tarr, Putnam Ave., plans to build a 2 story church including a steam heating plant on Second Blvd. About $500,000. Archt. not yet selected.

Mich., Detroit—The Bd. Educ., 50 Bway. Ave., has asked for an appropriation for plans for a 20 story, 100 x 100 ft. office building including a steam heating system, at Gratiot and Library Aves. About $1,000,000.

Mich., Detroit—The Bd. Fire Comrs., Wayne and Larned Sts., will receive bids until Nov. 22, for a 2 story, 90 x 90 ft. pumping station at Randolph St. and Detroit River. Bids will be received later for 2 motor-generator sets, 6 high-pressure pumps, vacuum pumps, etc. Smith, Hinchman & Grylls, 710 Washington Arcade, Engrs.

Ill., Chicago—The B'nai Abraham Zion Congregation, c/o Levy & Klein, Archts., 111 West Washington St., will soon award the contract for a 1 story, 126 x 165 ft. synagogue including a steam heating system, on Washington Blvd. and Karlov Ave. About $250,000.

Ill., Chicago—Cohan & Harris, 226 W. 42d St., New York City, are having preliminary plans prepared for a 1 story 100 x 135 ft. theater at 121 North Clark St., here, including a steam heating system. About $400,000. A. N. Rebori, 410 South Michigan Ave., Chicago, Archt.

Ill., Chicago—The Stearns Bros. & Co., 619 South La Salle St., will soon award the contract for a 3 story, 100 x 160 ft. printing plant including a steam heating system at East Huron St. and Fairbanks Court. About $200,000. Berlin, Swern & Randall, 19 South La Salle St., Archts.

Wis., Marshfield—The Bd. Pub. Wks., c/o John Seubert, City Clk., is having plans prepared for a 1 story, 36 x 40 ft. addition to power house. About $25,000. Cahill & Douglas, 217 West Water St., Milwaukee, Engrs.

Wis., Waukesha—The U. S. Public Health Service Hospital is in the market for one 125-hp. boiler. Lester McQuilkin, Supt.

Wis., West Bend—The West Bend Aluminum Co. is having preliminary plans prepared for a 2 story boiler and power house on Main St. About $75,000. Federal Engr. Co., Stephenson Bldg., Milwaukee, Engr.

Wis., West Bend—The Miller Spouting Co., Inc., P. O. Box 425, is receiving bids for twelve 220-volt, 60-cycle, three-phase motors, switchboard, air compressors, etc.

Iowa, Council Bluffs—The Women's Christian Assn., Mrs. E. Lucas, Chn., is having plans prepared for a 3 story addition to the Jennie Edmundson Hospital including a steam heating system. About $350,000. J. Chris Jensen, 305 West Bway., Archt.

Iowa, Mason City—The North Iowa Lutheran Hospital Assn. plans to build a 4 story addition to the hospital including a steam heating system, at 3rd St. and Georgia Ave., N. E. About $300,000. Rev. Richard Vordale, Secy.

Iowa, Pocahontas—C. Gilchrist, Co. Aud., will receive bids until Nov. 23 for a 2 story, 80 x 125 ft. court house including a steam heating system. About $400,000. Proudfoot, Bird & Rawson, 810 Hubbell Bldg., Des Moines, Archts. (Incorrectly noted Nov. 9.)

Minn., Minneapolis—The State Bd. of Control, D. F. Mullen, Secy., Capitol, St. Paul, received bids for a steam heating system in the proposed 3 story music building at the State University campus, here, from H. Kelly Co., 925 Plymouth Bldg., $42,000; Archambo Htg. & Plbg. Co., 315 5th Ave., S., $42,540, and M. J. O'Neil, 608 Exchange Bank Bldg., St. Paul, $43,076. Noted June 15.

N. D., Fargo—The Young Men's Christian Assn. plans to build a Y. M. C. A. building including a steam heating system. About $275,000.

Wyo., Douglas—Prince, Nixon & Co., Engrs., Omaha, Neb., will soon receive bids for the installation of a water system, here, including a pump house, engines to be driven by fuel oil, etc. About $75,000.

Ark., Cotter—The Dixie Power Co., Title Guaranty Bldg., St. Louis, Mo., is having plans prepared for a hydro-electric dam on the White River, here. Col. Henry A. Allen, 23 Metropolitan Block, Chicago, Ill., Engr.

Tex., Dallas—Ben Ablon, Cadiz and Santa Fe Sts., will receive bids until Jan. 1, for an ice and cold storage plant consisting of a 4 story, 100 x 150 ft. building and four 1 and 2 story buildings, 40 x 100 ft. each. About $500,000.

Tex., Terrell—The City Commission will receive new bids for two 5-in. two-stage centrifugal pumps, 500 to 800 gal. per minute against a 200-ft. head, direct-connected to two- or three-phase, 60-cycle, 2,200-volt electric motor, adequate to operate pumps at full capacity; installation to be made complete with all wiring, etc. Also as counter proposal, two 5-in., three-stage centrifugal pumps, 500 to 800 gal. capacity, belted to two or three 75 hp. oil engines of high compression type. Former bids were rejected. Noted Oct. 19.

Tex., Waco—The Methodist Orphanage, Herring Ave., is having plans prepared for a dairy barn and a steam or hot water heating plant for the orphanage. About $45,000. Address Ed. McCullough, 1108 North 18th St.

Okla., Big Heart—The Big Heart Light & Power Co., recently incorporated, plans to install two units and is in the market for meters, transformers, etc. P. J. Minck, Secy.

Colo., Greeley—The Colorado Milling & Elevator Co., 1441 7th St., Denver, is having plans prepared for a flour mill, here. About $350,000. Supt. of company, Archt.

Wash., Tacoma—The Olympic Ice & Machine Co., 612 East 25th St., plans to build a 4 story, 100 x 130 ft. ice plant. About $125,000.

Cal., San Diego—The San Diego Consolidated Gas & Electric Co. has applied to the State Water Commission for permission to utilize waters of the west fork of the San Luis Rey River for the development of 775 hp. Plans include dam and conduit. About $235,000.

Ont., London—J. C. Nichols, R.R. 2, Wilton Grove, will have plans prepared for a new dairy, creamery and milk plant on East London St., here. About $250,000.

Que., Westmount—The City Engr. will receive bids until Dec. 1 for 4,000 ft. of cable and a power house switchboard.

CONTRACTS AWARDED

Mass., Brookline (Boston P. O.)—The Commonwealth of Mass., Met. Dist. Comm., 1 Ashburton Pl., Boston, has awarded the contract for a pumping engine at the Chestnut Hill pumping station, here, to the Worthington Pump & Mach. Corp., 20 Devonshire St., Boston, at $75,900.

Mass., Hyde Park (Boston P. O.)—The Edison Electric Illuminating Co., 39 Boylston St., Boston, has awarded the contract for a 1 story, 25 x 50 ft electric substation on Hyde Park Ave., here, to F. F. Jonsberg Co., 15 Ashburton Pl., Boston, at $12,000.

Conn., Bridgeport—The City Engr., c/o Bd. of Bldg. Comnrs., has awarded the contract for a 1 story, 25 x 30 ft. pumping station to be known as the Black Rock pumping station to the Bridgeport Constr. Co., 983 Broad St., at $32,000.

Conn., Hartford—The Travelers' Insurance Co., 700 Main St., has awarded the contract for a printing plant on Albany Ave., to Marc Eideltz, 30 East 42nd St., New York City, at $1,000,000.

N. Y., New York—The Liberty Nat'l Bank, 120 Bway., has awarded the contract for alteration to bank including a steam heating system at 100 Bway., to the Thompson-Starrett Co., 49 Wall St., at $400,000.

N. Y., Staten Island—The Bd. of Welfare, Municipal Bldg., New York City, has awarded the contract for the installation of boilers in the proposed addition to present boiler house at the Sea View Hospital, here, to the Almerall & Co., 1 Dominick St., New York City, at $79,789.

Pa., Philadelphia — The Harbison's Dairies, Front and Diamond Sts., has awarded the contract for a 2 story, 80 x 196 ft dairy plant and boiler room to Barclay-White & Co., 1713 Sansom St., at $240,000

Mich., Detroit—The Bank of Detroit, Fort St., has awarded the contract for a 3 story, 50 x 140 ft. bank including a steam heating system to Hazelton & Clark, Book Bldg., at $300,000.

Wis., Janesville—The City has awarded the contract for a pumping engine to the Murray Iron Wks., 880 Washington St., Burlington, Ia., at $46,538. Noted Sept. 14

Minn., Fridley—The Walsh Tie Co., H. S. Gilkey, Secy. and Treas., 954 McKnight Bldg., Minneapolis, has awarded contract for a creosoting plant here, including a steam heating plant, to C. F. Haglin & Sons, 226 Lumber Exchange, Minneapolis. About $300,000.

Kas., Wagstaff—E. A. Hadley, Chief Engr. for the Missouri Pacific R.R. Co., Railway Exchange Bldg., St. Louis, Mo., has awarded the contract for a water works system including pump house, dam, etc., here, to E. Nelson & Sons, 3240 South Michigan Ave., Chicago, Ill. About $90,000

Tex., Dallas—The City has awarded the contract for furnishing and installing an electrically driven centrifugal pump with daily capacity of 25,000,000 gal., to Jones & Allinger, at $82,000.

Tex., Denison—The Missouri, Kansas & Texas Ry. Employees' Assn. has awarded the contract for a 3 story hospital to the Munn Constr. Co., at $300,000.

Colo., Denver—The City has awarded the contract for a 2 story, 125 x 350 ft. junior high school at South Washington and South Pearl Sts., Beard and Cedar Aves. to Simpson & Sullivan, Interstate Trust Bldg., at $400,000. A steam heating system will be installed in same.

Wash., Seattle — The Seattle School Board, Central Bldg., has awarded the contract for a 3 story, 126 x 250 ft. warehouse and shop to the Puget Sound Bridge & Dredging Co., at $247,380. A steam heating plant will be installed in same.

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